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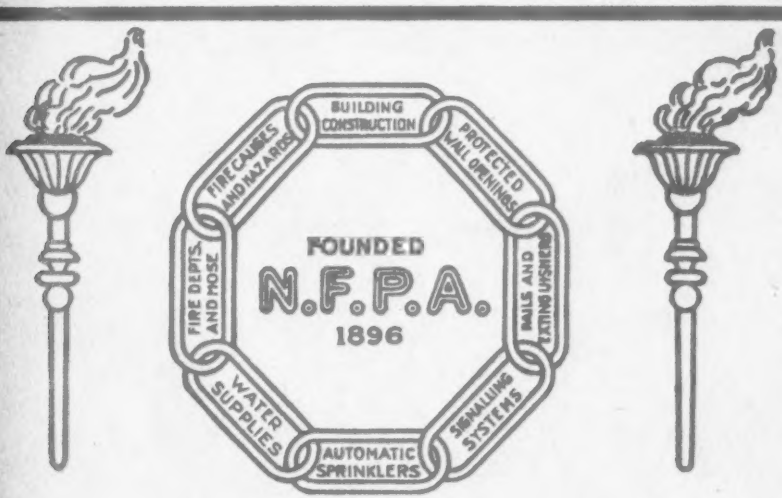
QUARTERLY
OF THE

NATIONAL FIRE PROTECTION ASSOCIATION



"To Promote the Science and Improve the Methods of Fire Protection and Prevention."

PUBLISHED QUARTERLY AT BOSTON, MASS., BY THE
NATIONAL FIRE PROTECTION ASSOCIATION

Printed in U. S. A.

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Vol. 34 October, 1940 No. 2

QUARTERLY

OF THE

National Fire Protection Association

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60 BATTERYMARCH STREET, BOSTON, MASS.

National Fire Protection Association

INTERNATIONAL

A NON-PROFIT TECHNICAL AND EDUCATIONAL ORGANIZATION

To promote the science and improve the methods of fire protection and prevention.

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

International.

Débris littered grounds and flaming ruins marked the site of Hercules Powder Company plant at Kenvil, N. J., following the fire and explosion of September 12, 1940. Forty-nine persons lost their lives and between 100 and 200 others were reported injured. Further details of this disaster appear on page 174.

The Quarterly

Vol. 34 October, 1940 No. 2

Fire Defense. America has long been the most profligate among the nations of the civilized world in her fire waste. Members of the National Fire Protection Association have for years been comparing the enormous fire losses in the United States and Canada with the relatively small losses in European countries. Now, with war defense uppermost in the popular mind, we discover the strange paradox that the very conditions that we have for so long lamented have prepared us, far better than European nations, in a very important phase of defense, that against fires due to bombing and other war incendiarism.

Incendiary fire is a major weapon of modern warfare. Destruction by fire, as contrasted with destruction by explosives, is not limited to single points, but propagates itself. The possibilities of fire have been utilized in the present war as never before owing to the development of aircraft. The photographs in the article "Total Fire" printed in this issue of the QUARTERLY show this all too clearly. For this reason the thought of the fire protection fraternity in the United States and Canada is focused on defense against war incendiarism.

Whatever may be our lack of preparedness in lack of military equipment and training, the peace-time fires of recent decades have given America all too abundant experience in fighting the same sort of fires that may be expected in time of war. For fire and its many attendant problems are essentially the same whether due to some act of carelessness or an incendiary bomb, arson to collect insurance or sabotage by foreign agents. Explosions due to the careless handling of flammable liquids, gases, and chemicals cause destruction all too similar to that due to explosive bombs dropped by bomber planes. Floods and hurricanes have given our fire departments experience in handling fires under emergency conditions where normal communications are disrupted, roads blocked, and water supplies out of service. The fire departments in our larger cities know what it is to fight a number of major fires simultaneously in different parts of the city. Mutual aid plans for inter-community assistance have integrated the fire defenses of smaller cities in many parts of the country.

American fire defenses are far short of what they should be, even for peace-time needs, but the normal complement of fire department personnel and equipment in American cities is several times as great as in Europe. In

America the emphasis has been placed on extinguishing facilities. Europe has relied primarily on personal habits of carefulness. As a result, public fire protection in America, despite all its deficiencies that we so well recognize, is probably far superior to that in Europe in trained personnel, and in amount and distribution of equipment, even with auxiliary fire fighting personnel and equipment such as have been added to augment the British fire service during the war emergency. This, however, is no ground for complacency, for in American cities we have the offsetting factor of the greater use of combustible construction, and the possibilities of sweeping conflagrations, particularly in closely built residential areas. Also, the American practice of concentrating manufacturing operations and storage of commodities in large units subject to a single fire makes us peculiarly vulnerable to large scale fire destruction.

* * * * *

Defense Industry Fires and Explosions. Production facilities in many of our vital defense industries are all too limited and the prevention of fires and explosions which might seriously curtail these facilities is accordingly of major importance — of far greater importance than under peace-time conditions when only monetary damage may be at stake. Many of these industries involve inherently hazardous processes. With increased production, the hazards are multiplied and the utmost vigilance is needed to prevent both accidental fire damage and destruction due to possible sabotage. The distressing explosion in New Jersey described in an article in this issue of the QUARTERLY and pictured in the frontispiece is an example.

There is no simple formula or panacea for the special fire problems of the defense industries. Each must be considered separately on an engineering basis and the best thought of the fire protection fraternity should be directed upon this problem. Fortunately the general methods of fire protection, well established through years of research and experience, are applicable to our present problems. To the fire protection engineer there is nothing unusual or mysterious about fire protection for the defense industries. Established methods of fire prevention and fire protection, intelligently applied, should keep losses at a minimum.

* * * * *

City Fire Loss Results. With the present realization that local fire loss experience reflects directly upon the fire prevention sincerity and efforts of a community, the days when an annual fire loss of $3.00 to $5.00 per resident could be regarded with complacency are gone. As a matter of record, the median fire loss per person for U. S. cities of over 100,000 population was $1.39 in 1939. At the present time, a city with normal hazards and usual luck can expect an annual fire loss of less than $2.00 per person. A loss of that magnitude in most cases reflects no special credit upon the local fire

prevention efforts. A community that carries on a systematic fire prevention campaign, including inspection of dwellings, usually can expect to keep its average loss below $1.00 per person each year.

It might be in order to suggest that residents of any city reporting a fire loss above $1.00 per person annually should inquire as to why such losses are tolerated in their cities. If such losses are the result of an excessive number of building fires, fire prevention inspection services may not be adequate, or wooden shingle roofs or some other structural defects may be causing numerous fires. If, on the other hand, it is found that a large annual fire loss in the city is the result of one or more unusually large losses, there may be indications that the fire department has failed to impress upon the owners of high value properties the importance of providing adequate private protection to safeguard unusual hazards that public fire departments cannot be expected to cope with adequately no matter how prompt or efficient their response may be.

In a minority of cases it may be found that excessive fire losses are directly due to the inadequacy of the public fire fighting forces and their inability to handle routine fires. Even in such cases, however, the best remedy would appear to be an immediate redoubling of fire prevention efforts in order to reduce the frequency of fires to the lowest possible point while local fire defenses are being strengthened.

* * * * *

The Fire Bird Ballet

On Tuesday evening, August 27, an audience estimated at thirty thousand people assembled in Hollywood Bowl to hear the Bowl orchestra play Igor Stravinsky's popular "Fire Bird Suite." In the audience was the well-known radio music commentator, Deems Taylor. Following the playing of the Stravinsky number, Mr. Taylor was introduced. He proposed that in honor of Stravinsky, the lights be extinguished and at a given signal a match be lighted by each person in the vast audience who had one, or could borrow one from his neighbor. This was done.

It was a very impressive feature and nobody's clothing was ignited. Consequently there was no cause for panic or possible personal hurt. The event recalled to one member of the audience the ignition of a woman's gown by a match in a New York restaurant some years ago, and her burning like a torch on the balcony outside the window through which she bolted in fear and agony. Possibly Stravinsky's "Fire Bird" has an occult influence in restraining or appeasing the fire fiend who does not always fail to take advantage of unconscious human ineptitudes that furnish opportunities for tragedy.

Total Fire—The Incendiary Bomb.

By John A. West, Jr.,
N.F.P.A. Staff.

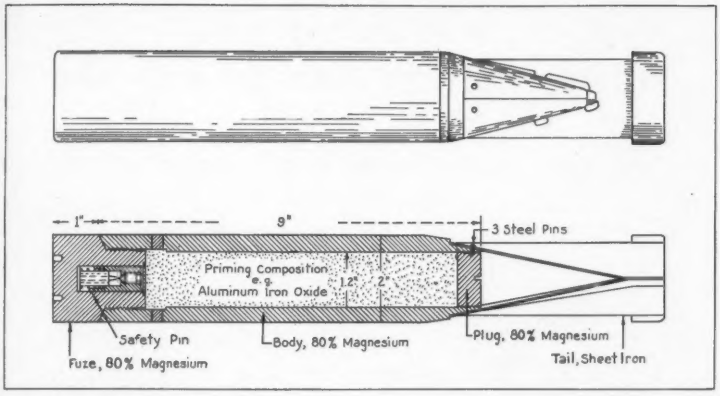
Until September 1939, the greatest proving grounds of all times for implements of destruction had been World War I. Outstanding example of implements which proved their worth were submarines, which revolutionized naval warfare, and tanks and poison gases, which added to the horrors of land operations. How many implements of destruction will be put to test on the proving grounds of World War II remains to be seen. The first year of the war has already produced magnetic mines, dive bombers, incendiary bombs and many others. All have been destructive. Perhaps none has the potentialities of being so completely destructive and paralyzing (when more fully developed) as the incendiary bomb.

Incendiary bombs serve two major purposes. First, objectives are made visible to raiding planes, thus minimizing the effectiveness of blackouts. Second, sweeping conflagrations, more devastating than tons of explosives, may result from the fires that are kindled by such bombs. For although a single explosive bomb can result in a tremendous amount of damage, such damage is localized. Fire, on the other hand, is propagated readily and rapidly. A single small incendiary bomb may result in the destruction of an entire city, particularly when the factors which tend for conflagrations are all working together as they usually are in times of war.*

Factors which contribute to the spread of fire and conflagration are numerous and include wooden shingle roofs, high wind velocities, lack of exposure protection, hot or dry weather, failure of water pressure, fracturing of water mains, and inadequacy of fire department. Thus, during war, water mains may be shattered by explosions; such large numbers of fires may occur within a city that the fire department and auxiliaries are unable to cope with them. Not a very great conflagration factor in Europe, however, is the wooden shingle roof, the greatest conflagration factor in the United States. For unlike the United States, wooden shingles have for the most part long since disappeared in Europe. Use of incendiary bombs against many urban districts in the United States might very well prove disastrous because of such roofs.

Although the effective incendiary bomb as it is known today has been developed during the first year of the present war, it would be incorrect to say that such a bomb is strictly a product of World War II. Bombs of an incen-

*The destructive powers of an effective incendiary bomb were predicted in 1936 in "Warfare by Fire," an editorial appearing in the April issue of the N.F.P.A. QUARTERLY that year.



Air Raid Precaution Handbook No. 9, British Government.

Drawing and cross-sectional view of a typical one-kilogram Electron bomb. Note blunt nose and awkward streamlining. With the exception of the sheet iron tail and firing mechanism, the bomb is constructed entirely of incendiary materials.

diary type were introduced during World War I, but were apparently ineffective. The reasons for their ineffectiveness were several.

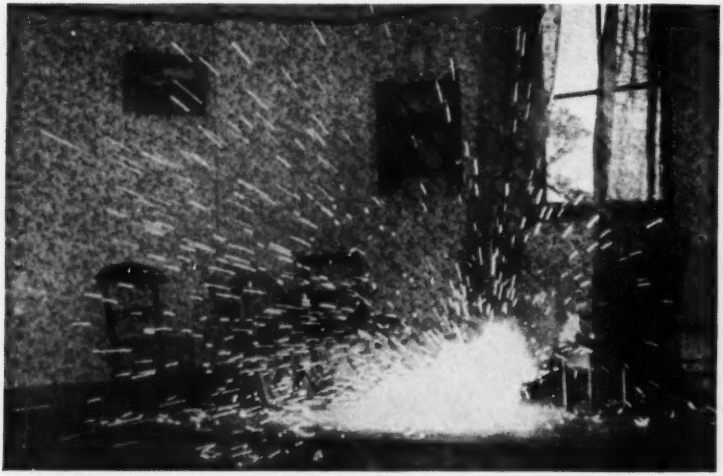
First of all, the construction of the bombs themselves did not permit for effectiveness. They were of two types. The first consisted of a steel shell inside of which there was a charge of thermite, i.e., iron oxide and powdered aluminum. Upon the ignition of this charge, the powdered aluminum and iron oxide reacted violently (producing molten iron and liberating tremendous amounts of heat)—

$$8Al + 3Fe_3O_4 \rightarrow 4Al_2O_3 + 9Fe$$

However, once the steel shell had been penetrated by the heat, the reaction was very nearly completed.

In the second type of bomb, the incendiary material was gasoline or some other highly flammable liquid in varying amounts from one to ten kilograms (¼ to 2½ gallons). Upon impact, this liquid was fired, but with such small amounts of gasoline, the resultant fire would tend to burn itself out before penetrating and setting fire to the immediate surroundings. Only when the bomb struck very near some readily combustible substance was there any great danger.

The effectiveness of any type of bomb also depends to a large extent upon the efficiency of the bombing plane. In World War I, the bomber was insufficiently developed to make mass raids possible. Now, the situation is changed. With one year of World War II already behind us, bombing has been done on a large scale. The mere fact that the use of incendiary bombs is not only being continued but also accelerated, would seem to indicate that such bombing is



Air Raid Precaution Handbook No. 9, British Government.

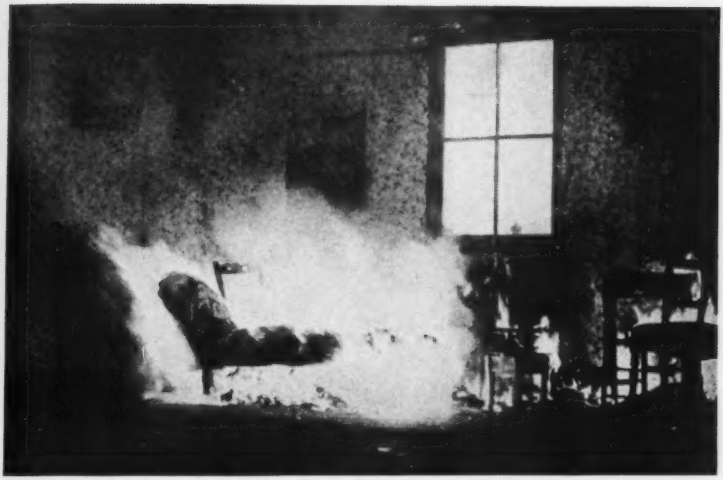
A one-kilogram magnesium incendiary bomb fifteen seconds after impact and ignition.

effective. To substantiate that indication, are the numerous reports and pictures that reach us through strict censorship. Facts concerning the construction of such bombs, and the methods of protection against them, however, have filtered through very slowly.

The Electron Bomb.

All types of bombs are capable of setting fire to flammable materials. In fact, the fires which oftentimes occur as a result of explosive bombing are far more destructive than those which are "touched off" by the regular incendiary bomb, because the destruction and débris which are wrought by the explosion sometimes make it impossible for fire fighters to reach the seat of the fire. But explosive bombs are heavy. The number of such bombs that can be carried in the racks of the average bomber is not large, usually well under fifty. On the other hand, an incendiary bomb which has been developed and which weighs, in smaller sizes, only one kilogram or approximately 2.2 pounds, makes it possible for a single bomber to carry 2000 bombs. This small incendiary bomb is called the Electron bomb.

The one-kilogram Electron bomb makes use of its thick-walled 80% magnesium shell to spread its fire. This shell is approximately 9 inches in length and 2 inches in diameter and contains within it several ounces of a thermite mixture. Unlike the thermite type incendiary bombs used during the last World War, however, this thermite serves only to ignite the magnesium shell; it is not the main incendiary material.



Air Raid Precaution Handbook No. 9, British Government.

Fire caused by a one-kilogram magnesium incendiary bomb forty-five seconds after impact and ignition.

The thermite reaction within the shell is set off by an igniter on either the nose or tail of the shell. This igniter consists merely of a needle which is driven into a small percussion cap by the impact of the bomb.

Unlike other types of bombs, the Electron bomb does not explode upon impact, but rather, the thermite reacts violently for nearly a minute at a temperature of about 2500° C. (4532° F.). Jets of flame emit from vent holes in the shell and bits of molten magnesium which are forced through these holes scatter in every direction for a distance of about fifty feet. This scattering of incendiary material ends when the thermite reaction has been completed and the pressure within the bomb has been decreased. However, the magnesium shell has been ignited by that time and will burn for 10 or 15 minutes at a temperature of approximately 1300° C. (2372° F.), setting fire to any combustible material within a radius of a few feet.

Electron bombs are usually dropped from a height of a mile or more and reach their maximum velocity of 350 feet per second after they have dropped approximately 5000 feet. They are not dropped singly, but in lots of ten or twenty from containers. It is possible to drop the contents of more than one container at the same time.

The number of these one-kilogram Electron bombs that a single bombing plane can carry ranges all the way from 1000 to 2000, but the number of fires that will result is not necessarily 1000 or 2000. Quite the contrary. In order to do any appreciable damage, the bomb must hit and penetrate the roof of a

Acme.

London at midnight. Fires kindled by incendiary and explosive bombs light up the city and tend to make the blackout ineffective. The white patch in the Thames below London Bridge may mark the spot where an incendiary bomb of the one-kilogram type has struck the river.

building. Those bombs which strike bare ground, including streets, yards, parks, etc., will in almost every instance burn themselves out. Assuming then that only 15 per cent of the average urban district is built over, the number of bombs out of 1000 that would probably make direct hits upon buildings is only 150. Of this number, it is likely that half would either glance off the roof or fail to penetrate because of the construction of the roof. Of the 150 bombs striking a building then, perhaps not more than 75 would actually be capable of starting serious fires.

The area over which these 75 fires would be scattered would depend upon the speed and height at which the plane was flying and the distance covered while it was dropping its load of bombs. At 5000 feet, flying 200 m.p.h. and dropping 20 Electron bombs a second, the bomber would spend its cargo of 1000 bombs while traveling only three miles, and set fires in every sixty yards approximately. If several bombers are participating in the raid, the number of fires set would increase proportionately.

Although the powers of penetration of the one-kilogram Electron bomb are relatively poor, such a bomb will ordinarily penetrate an ordinary wood roof deck and covering material when dropped from a height which allows for maximum velocity upon impact. The possibilities of the bomb penetrating to lower floors, however, are not very great, and therefore, it is likely that

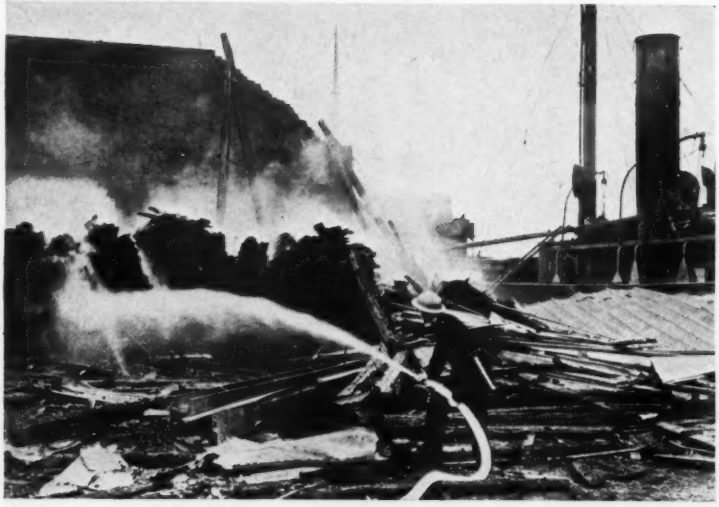
International.

Firemen in Southampton, England, fighting fire in a furniture warehouse, which was caused by incendiary bombing. One hundred persons were trapped in an air raid shelter below the ruins at the right. When they were rescued later, none was found seriously hurt.

when a fire occurs as a result of an incendiary bomb, it will do so in the attic floor of the building. And inasmuch as the attic is usually less accessible than the floors below, the fires which will occur there will be that much more difficult to extinguish. Tests have shown that a one-kilogram incendiary bomb will penetrate three and a half to four inches of reinforced concrete, about six inches of sand or earth, or one-quarter inch of mild steel plate.

Although the Electron bomb may penetrate the roof only, it is very possible for the resultant fire to spread rapidly to the lower floors of the building, particularly if there are cracks, crevices, or any other openings in the boarding between floors which will permit the flow of the molten magnesium. If there is no attic floor and the ceiling is lath and plaster only, the bomb will probably penetrate that ceiling within a few seconds if not at once. The rapidity with which the bomb ignites the roof and the roof space depends upon the amount of timber and other combustible materials contained therein.

Owing to the lightness of the one-kilogram Electron bomb and its awkward streamlining, any degree of accuracy in dropping it is impossible. The contents of a single container (ten or twenty bombs) dropped at the same instant from a height of 5000 feet, for example, might disperse as they dropped and strike anywhere within an area of 10,000 sq. yards.



Acme.

Lumber goes up in smoke along the London waterfront. Note steamer at right which does not seem to have been damaged by fire. Also note garb of steel helmeted fireman and charred ruins strewn about him.

For that reason, the use of the one-kilogram bomb is reserved for indiscriminate bombing only, while heavier bombs of similar construction are used when specific targets are sought, as for example, factories, supply bases, and munition dumps. These other Electron bombs range in weight from two to twenty-five kilograms, or from 4.5 to 55 pounds.

The Electron bomb is undeniably one of the most if not the most efficient bomb that has ever been devised. For outside of its sheet iron tail and the mechanical igniting mechanism, it is constructed entirely of incendiary material. The heavier Electron bomb sometimes has a steel nose to increase penetrating power and bombing accuracy.

Protection Against the Electron Bomb.

Methods of protecting one's home against fire by the Electron bomb consist of making the timber and flooring of the roof space impregnable to both fire and penetration of the bomb, and of keeping extinguishing apparatus in readiness for any eventuality.

Unless preventive measures are taken, the Electron bomb once it has penetrated the roof of a building will burn its way through the flooring of the roof space within a relatively short period of time and spread fire on the floors below. The initial problem, then, is to find some suitable fire-resistive material with which to cover the flooring of the roof space. Tests have shown that

Pictures, Inc.

Street scene in London following incendiary bombing. Note ladder in distance and hose streams being played into gutted buildings. Flames from gas main may be seen in left center. As long as the gas is burning, there is no danger of explosion.

Acme.

The dome of St. Paul's Cathedral in London pierces the smoke and flames which surround it.

Pictures, Inc.

London firemen fighting a huge blaze caused by incendiary bombs dropped by German raiding planes.

International.

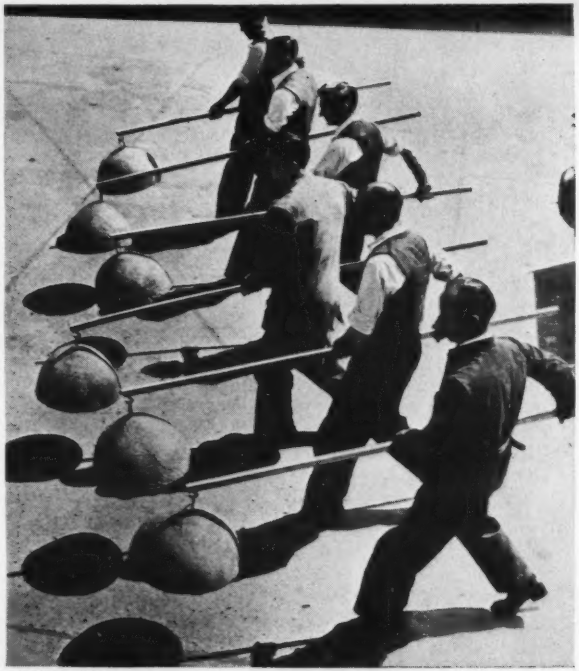
Incendiary bombs dropped indiscriminately spare no building. Firemen above are trying to save as much as possible of this church located "somewhere in England."

Acme.

"Somewhere in London" this five-story mercantile building was entirely gutted by flames during the preceding evening.

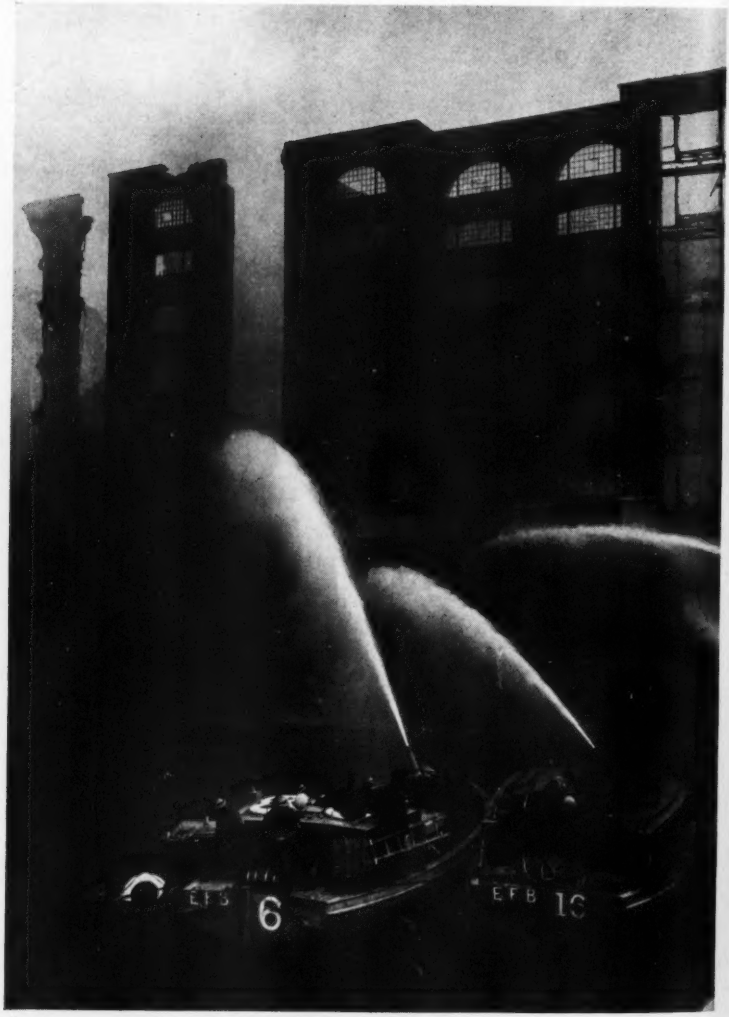
British-Combine.

A group of auxiliary firemen in London who tackled and successfully extinguished forty incendiary bomb fires within their district. Note bucket hand pumps carried by the men and the thirty-foot lengths of hose.



British-Combine.

"Snuffers" to extinguish incendiary bombs by smothering them. These "snuffers" are made of wire mesh sprayed both inside and out with asbestos fibre. They are called the latest device for dealing with "Enemy No. 1," the incendiary bomb.



Acme.

Emergency fireboats Nos. 6 and 16 on the Thames fighting dock fires caused probably by incendiary bombs of heavier types. Small fireboats such as the ones shown here are probably more effective for fighting dock fires than large boats. The small boats are more easy to maneuver and have greater speed. However, they do not have sufficient capacity for major building fires.

some degree of protection is afforded by a two-inch layer of dry sand over some type of building paper to keep the sand from running through the cracks between the boards. Other materials which may be used in place of sand are listed in the accompanying table.

Materials Shown by Test to Give Protection to Floors Against Burning by the 1-kilo Magnesium Incendiary Bomb.

From "Incendiary Bombs and Fire Precautions" published by the British Government.

Material	Minimum layer inches	Weight per sq. ft. lb.	Remarks
Brick dust	1½	9.5	Can be used in place of sand.
Slate dust	1¼	5.0	
Foamed slag (ground)	2	5.5	
Pumice (ground)	1¼	4.0	
Household ash	2¼	5 0	
Boilerhouse ash	1¾	6 0	
Kaolin	1½	7.0	
Ground chalk	1¼	6.0	These carbonates stimulate the burning of magnesium, but can be used as protective layers.
Ground limestone (⅛ mesh-dust)	1¼	10.0	
Ground dolomite (⅛ mesh-dust)	1¼	10.0	
Asbestos Millboard	¾		Can be used as protective layers.
Asbestos wood			
Asbestos wall board (types which do not fracture under heat)			
Sprayed asbestos (certain types)			
Asphalt compositions (certain types)			
Magnesium oxychloride composition (certain types)			
Rock anhydrite or gypsum composition (certain types)			
Ballast concrete	1		
Ash concrete			
Wood concrete (equal volumes oak sawdust and cement)	½		

Because sand and other granular materials will be scattered by the impact of the bomb and because the heat and fire escaping from the vent holes of the bomb will eat passages through such granular materials to the flooring below, either some plaster or sheet material which does not have the objectionable properties of granular materials is preferred. In addition to protecting the flooring of the roof space, the timbers and other combustible construction above should be protected by a coating of fire-resistive paint or plaster, for otherwise such material will surely be ignited by the intense heat of the bomb.

The Electron bomb can be extinguished in any one of several ways, and of course, the idea is to extinguish it or bring it under control before it has been the beginnings of a major fire.

While the thermite reaction is in progress, the bomb cannot be smothered because the oxygen that enters into the reaction comes not from the outside

Air Raid Precaution Handbook No. 9, British Government.

Water being applied to a burning incendiary bomb of the one-kilogram type. The jet from the hose should be played into the seat of the fire. Spray surrounding the jet serves to wet down combustible materials and to stop the spread of the fire. The person at the hand pump should be at least 30 feet from the nozzle. (See photographs pages 104 and 105 for start of this fire.)

atmosphere, but from the iron oxide. When the thermite reaction has been completed, however, and the magnesium shell is burning, the bomb is dependent upon the outside atmosphere for its oxygen and can be smothered.

Although water accelerates the burning of magnesium, the acceleration cuts the burning time of from 10 to 15 minutes down to two or three minutes. Therefore, water can be used to combat the bomb if properly used. The reaction between the hot magnesium produces the hydroxide of magnesium and free hydrogen.

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

The latter ignites and will burn without any real damage so long as the water is applied sparingly. If, however, water is put on too fast, the hydrogen may accumulate faster than it can burn, and explode violently.

To prevent an explosion and to keep the bomb under control at the same time, a jet surrounded by a spray of water has been found most satisfactory by the British authorities. To produce this jet and spray, a one-eighth-inch nozzle supplied by hose from a bucket hand pump at least 30 feet away is also recommended. The delivery from this system should be not more than one and three-quarters gallons a minute. The main jet of water should be played into the seat of the fire and not indiscriminately into the smoke and flame. The spray serves to wet down the area surrounding the bomb and thus prevents the spread of fire.

British-Combine.

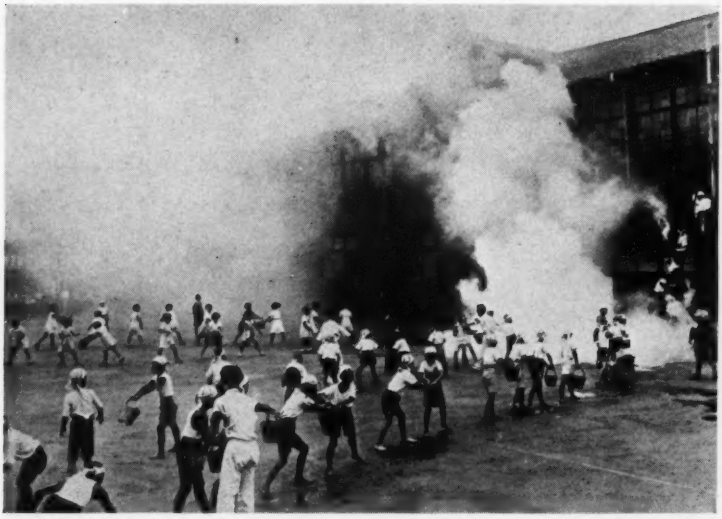
Auxiliary fireboats on the Thames fighting huge warehouse and barge fires. To extinguish a warehouse fire once it has made headway is almost an impossibility. Firemen can only hope to stop the spread of fire to other buildings.

Since the water will cause scattering of bits of burning magnesium, it is best that the person directing the water stream use extreme caution while doing so and that he neither stand up nor exert himself physically. Although two persons can manage the work, three persons should be on hand, two at the pump and one at the nozzle. Water should never be poured onto an Electron bomb from a pail or bucket. A common garden hose would probably serve the purpose if the water supply could be depended upon.

Other Measures for Protection.

Sand and other granular materials, such as slag, pumice, ash and kaolin can be used effectively to bring the Electron bomb under control, but such materials will not extinguish the bomb. The bomb should be thoroughly covered with the material until the glare and heat have been reduced, and it is possible to scoop up both covering material and bomb and remove the whole into the open where the bomb can burn itself out without any great danger.

To remove the bomb in this manner, certain apparatus is required. The granular material should be poured over the bomb from a long handled scoop shovel, and when the heat and glare of the bomb have been reduced sufficiently, the shovel should be used again to pick up the bomb and its covering. Granular



International.

Japanese school children in Tokyo are taught how to fight incendiary bombs by a fire warden. Buckets of water should never be thrown at a blazing magnesium bomb.

material and bomb should then be placed in a suitable container filled with sand for transportation from the building. Once the bomb has been removed, any resulting fires can be extinguished by ordinary methods.

Numerous other materials and compositions have been discovered which can be used to combat the Electron bomb and probably others will continue to be discovered as the use of the bomb increases. Those discovered so far are either inferior to water or sand, or are materials which are extremely expensive or difficult to store. Of the various types of chemical extinguishers, only those of the water solution type would be effective against the Electron bomb, and probably more than one extinguisher would be required. The solution should be played upon the bomb in the same way as water from a hand-pump or hose.

Still another method that has been used to extinguish the incendiary bomb makes use of a "snuffer." This device is a large cup-shaped instrument which, when placed over the bomb, smothers it. The time required to complete the operation is said to be about 30 seconds.

Electron bombs range in weight from one to twenty-five kilograms. For indiscriminate bombing, the one-kilogram bomb is used, of which a single bombing plane can carry as many as 2000. Although these small bombs are in themselves simple enough to extinguish, the raider can be sure that at least a few of them will develop into serious fires. In theory, these fires will decrease

International.

Bombed oil tanks on the Thames. Effective bombing of petroleum storage requires an explosive bomb; small incendiary bombs may not ignite modern tanks. With modern tanks complying with the N.F.P.A. Flammable Liquids Ordinance, properly constructed, spaced and diked, such a fire should not spread to adjoining tanks. Without proper separation, as in the tanks in the foreground, fire spread from tank to tank may be expected. Smoke from the water at the top of this picture is characteristic of incendiary bombs.

Acme.

Widespread blaze and destruction in London probably caused by explosive rather than incendiary bombs. Owing to the damage created by the explosion, the seat of the fire is very often hard to reach.

morale, hamper production and transportation, and keep the fire department busy while the enemy is dropping Electron bombs of a heavier type on specific targets. The extremely heavy Electron bombs produce such heat and glare that experienced fire fighters are required to handle them. And the heavier the bomb, the greater its penetrating power. The 25-kilogram Electron bomb, for example, would probably penetrate to the lower floors of a building without much difficulty. Although the heavy Electron bombs are more difficult to combat than those of the one-kilogram type, these fires can be extinguished by the same methods.

Other Types of Incendiary Bombs.

Another type of bomb that has been used to a considerable extent during the present war is called a Multiple-Effect Bomb and is employed against specific and important targets. The bomb contains numerous separate incendiary units of either magnesium or phosphorus which are thrown from the bomb upon impact and ignition, and which scatter over a wide area. Such bombs usually have pointed steel noses instead of flat noses such as are used on the one-kilogram Electron bomb, and thus have great powers of penetration. The burning magnesium units can be handled in the same manner as the Electron bomb. The phosphorus can be treated with water also, but should be removed to a safe place before being allowed to dry. Phosphorus ignites upon

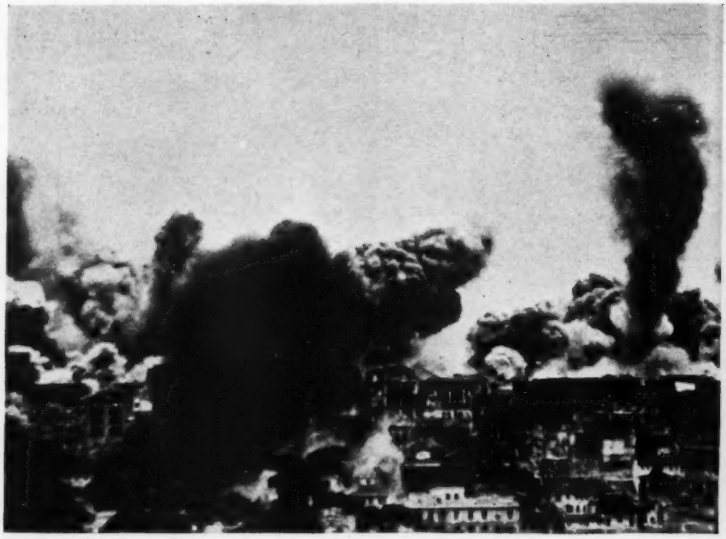
British-Combine.

A gas main blazes away at a street intersection in London. Firemen are wetting down surrounding buildings to stop the spread of fire from the main. Note in this and other pictures how travel through the streets is impeded by débris caused by the bombings. Result: firemen can not always arrive at the scene of fire in time to stop the spread of flames.

coming in contact with air. In addition, phosphorus is extremely poisonous and produces burns which are difficult to heal. Multiple-Effect bombs weigh approximately 12 kilograms.

Bombs containing gasoline, although used to some extent during the last war, have been used relatively little during the present conflict. Not only is the gasoline bomb rather ineffective, but also gasoline can be put to better uses elsewhere.

Phosphorus, already mentioned in connection with the Multiple-Effect Bomb, is rather ineffective as an incendiary agent because of its cool flame and slow burning properties. In addition to its use in the Multiple-Effect Bomb, however, it has also been used in another type of fire weapon of the present war. This weapon is a moist card which is small enough to fit into the palm of the hand. In the center of these cards is a mixture of guncotton and phosphorus. When the cards become dry, they burst into flame. Thousands of these cards can be carried by a single raiding plane and dropped indiscriminately from considerable heights.



International.

Bombing planes over China drop explosive and incendiary bombs on Chungking. The smoke to the right indicates explosions; to the left, rapidly spreading fire.

Fire Department Organization.

To extinguish incendiary bombs and the fires which result from the use of incendiary bombs, the belligerent nations have found it necessary to make a number of changes in their fire department organization.

In normal times, the British fire fighting forces are organized much the same as the fire fighting forces in the United States and Canada. However, there are a few differences. First, owing to the smaller number of fires and less general use of combustible building materials, the normal fire fighting forces are smaller, and fire stations are not so closely spaced. Second, the officers rather than working up through the ranks are given specialized training which corresponds to the leadership training such as that given at our military or naval academies. Third, the various types of fire fighting apparatus, although essentially the same as ours, are known by different names. Fourth, the fire brigade for each district is an entity within itself and for all fires that occur within the district that brigade is supposedly capable of handling the fire unless its magnitude is extreme.

To combat the large number of fires which would ordinarily occur when enemy planes drop as many as 2000 incendiary bombs each, the home defense in Great Britain has found it necessary to augment the fire fighting forces by

Acme.

Widespread fire along the London waterfront. The stream of water from behind the silhouetted fireman is probably being played upon buildings from an emergency fireboat.

organizing an "auxiliary fire service." The members of this auxiliary service have been given specialized training in extinguishing incendiary bombs and in fighting the resulting fires.

During and following air raid alarms or while communications are impaired, these auxiliary forces make rounds within their districts at prescribed intervals so that any fires which may be caused directly or indirectly by enemy planes can be extinguished. It has been reported that as many as forty to sixty incendiary bomb fires have been extinguished by small groups of the auxiliary firemen within two hours. In addition to increasing the land fire forces, the regular fire service on the Thames has also been increased by a large number of small boats. Auxiliary firemen have been given charge of many of these boats. The number of casualties among the fire fighting forces in England during the first year of the war is reported to be in the neighborhood of 500. Since the fires ignited by incendiary bombs make the firemen visible, many have been machine-gunned while in the line of duty.

In most countries of the continent, the fire fighting forces are a division of the regular armed forces. This is true in both Germany and Italy. Although it is known that numerous precautions have been taken to fight fires which result from incendiary bombing, just what precautions have been taken and with what result to peace-time organization of the fire fighting forces, is relatively unknown outside of these countries.

Conclusions.

The seemingly effective incendiary bomb makes possible arson on an international scale. To counteract the effective incendiary bomb and the antics of our international arsonists, however, is fire protection and prevention, a science fully developed and standing ready for any eventuality. Within the last twenty years, standards dealing with every conceivable fire hazard have been prepared by committees, the members of which are experts in their various fields. At regular intervals, these standards have been completely revised and brought up to date. The success of these various standards can be measured only in the steady decrease of fire losses.

Both technical and non-technical literature dealing with fire prevention and fire protection have been widely distributed by N.F.P.A. and other organizations. The widespread distribution of this material has continued in the past and will continue in the future to keep everyone conscious of the dangers of fire. For regardless of how a fire starts, whether it be from a carelessly discarded match or from an incendiary bomb, the methods by which the spread of fire is curtailed are exactly the same. And those who understand the scientific procedure for extinguishing and stopping the spread of fire resulting from ordinary peace-time causes are those who will be able to extinguish and stop the spread of fires caused by incendiary or explosive bombs during times of war. During World War I, the science of fire protection went undefeated by incendiarism; now during World War II, the science of fire protection will probably win again.

Like the early Spanish explorers who sought in vain for Eldorado, the land of honey and gold, belligerents are continually seeking for a device that will completely surprise and destroy the enemy before the enemy is able to find a device for counteraction. Since the beginning of time (and war) belligerents have been trying to find that device among incendiary agents. Thus far, it has not been found.

It seems doubtful that it will be found during World War II.

Magnesium and Its Alloys.

By H. S. Hirst and A. B. Guise,
Chemical Engineers, Factory Mutual Laboratories,
(Members N.F.P.A.).

Magnesium and its alloys are being used increasingly today for the production of light weight metal shapes and parts and for other special parts where the use of magnesium is desired because of some property of the metal other than the lightness. Since magnesium and alloys having high magnesium content will ignite readily when of moderate fineness and cannot be extinguished by usual methods, their increased use has resulted in increased fire hazards in industrial plants using magnesium alloys.

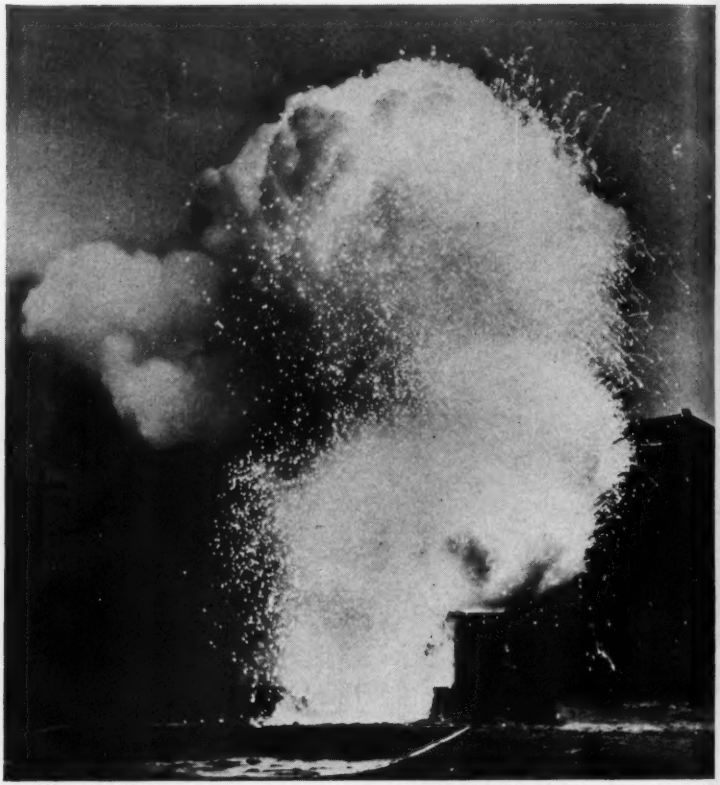
Magnesium is industrially used primarily in the form of alloys with aluminum in which the magnesium content is in the range of 90% to 98%. A common trade name for these alloys is "Dowmetal." The increasing use of magnesium alloys for light weight machine parts, forgings, sheets, and castings and die castings has brought attention to the fire hazard associated with the processing of magnesium alloys and storage of magnesium alloy chips and fine turnings.

Magnesium and alloys containing a large proportion of magnesium are now being worked industrially by many processes of which those listed below are representative:

1. Sand and permanent mold casting.
2. Die casting.
3. Forging.
4. Extrusion.
5. Production of plate, sheet and strip.
6. Machining.
7. Grinding.
8. Annealing and other forms of heat treating.

Magnesium reacts with water to produce hydrogen and magnesium hydroxide, the water supplying the oxygen necessary for combustion of the magnesium. The reaction is very slight at ordinary temperatures, but increases rapidly as temperatures increase. Water supplies this necessary oxygen much more rapidly than air, hence the extreme violence of the combustion of wet magnesium. The hydrogen produced introduces the additional hazard of a flammable gas.

At normal temperatures magnesium alloys react with water to only a negligible extent, but when the metal is burning the application of water or other common extinguishing agents, such as foam, carbon dioxide, vaporizing liquids (largely carbon tetrachloride), or dry chemical (mostly sodium bicar-



Heat applied to wet magnesium brought about this violent reaction. At ordinary temperatures, the reaction is only slight. Liberation of hydrogen increases as the temperature is increased.

bonate), will greatly intensify the rate of burning. The application of large quantities of water or vaporizing liquid may result in the burning taking place at an almost explosive rate. Similarly, although the dry or oily metal burns gently and relatively slowly, when scrap such as fine turnings is wet with water and ignited, the wet mass of metal will be consumed with almost explosive rapidity.

Since the usual extinguishing agents have no extinguishing effect on burning magnesium alloys, the best extinguishers for this type of fire are powdered talc, fine cast iron borings, fine dry sand or other material inert to magnesium.

Magnesium fires, unless fought with a proper understanding of the properties of the material, involve a serious personal hazard to firemen, as is shown by the fire experience reported in this article.

A hose stream was directed into this wooden shed where magnesium scrap was burning. Tremendous bursts of flame resulted.

Fire and Explosion Tests.

Numerous fire tests have been made to determine the burning properties of magnesium and its alloys, and to ascertain the most effective extinguishing methods. A number of tests were run with magnesium scrap turnings. The quantities used were the contents of 55-gal. drums. In some of the tests the scrap was ignited as received, wet with the kerosene used as a cutting oil. In these tests the scrap burned slowly. In other tests, the scrap was wet with water and when ignited the wet scrap burned with almost explosive violence.

Several previous tests had been made to illustrate proper and improper methods of extinguishing small fires in burning magnesium alloy chips. Water was used on a fire and resulted in a violent reaction. Vaporizing liquid as an extinguisher intensified the reaction but not with the violence of water, probably because only a small amount of extinguishing liquid was applied. Foam, carbon dioxide and dry chemical extinguishers, while not increasing the combustion of the magnesium alloy greatly, were of no value in extinguishing the fire. The extinguishing agent used successfully was powdered talc which was

shoveled gently on to the burning material, forming an air-tight blanket over the burning magnesium alloy. The hot magnesium required considerable time to cool to atmospheric temperature.

The action of the various common extinguishers shows that only a material inert to magnesium is effective in extinguishing such fires. Small magnesium fires have also been extinguished with lubricating oil, but this method is impractical on larger quantities of metal.

Laboratory tests have been conducted to determine the amount of hydrogen liberated by fine magnesium alloy turnings in contact with water at both normal and elevated temperatures. These tests show that while hydrogen is generated by magnesium alloy chips in contact with water, the rate of evolution is so small as to be practically unimportant from the standpoint of explosion hazard if ample natural draft ventilation is provided. However, if the magnesium alloy is in much more finely divided form such as dust, special arrangements should be made to provide adequate ventilation.

Dust explosion tests on powdered magnesium have been conducted by the Laboratories in the modified Clement-Frazier dust explosion bomb in which pressures as high as 69 lb. per sq. in. were recorded. As a measure of relative explosion hazard, similar tests in this equipment with aluminum powder have given pressures of 37 lb. per sq. in., and with cornstarch, pressures of 32 lb. per sq. in. were obtained.

The Industrial Storage and Handling of Magnesium and Alloys.

The most important recommendation for industrial storage and handling of magnesium and its alloys is the isolation of magnesium from water. The second is good housekeeping, with frequent removal of chips, fine turnings and other scrap metal, and storage in tightly closed metal containers well away from manufacturing areas, and third, proper protection for the collection and disposal of magnesium dusts. These recommendations are outlined in more detail below for specific processes using magnesium and its alloys.

MACHINING OPERATIONS. No water, even in mulsifiable cutting oils, should be used in machining operations. If dry machining is not practical, a mixture of kerosene or mineral seal oil and lard oil, or straight kerosene or mineral seal oil is preferable. Arrangements should be made to sweep the turnings away constantly from beneath the tool, so that if ignition of the magnesium alloy does take place at the tool, there will be no metal near by to which the fire can readily spread. The turnings should be frequently placed in a covered metal container and the containers should be emptied at the end of each shift into other tightly covered metal containers which should be removed from the manufacturing areas. It is important that no turnings should be left in these areas overnight. Turnings should preferably be stored in a non-combustible building in tightly covered metal containers separated from

other combustible material. Storage in a combustible building protected by automatic sprinklers is acceptable if containers are tight against the entrance of water. A large accumulation of turnings in storage should be avoided and the material should be returned to the recovery plant and melted down into solid ingot as soon as possible.

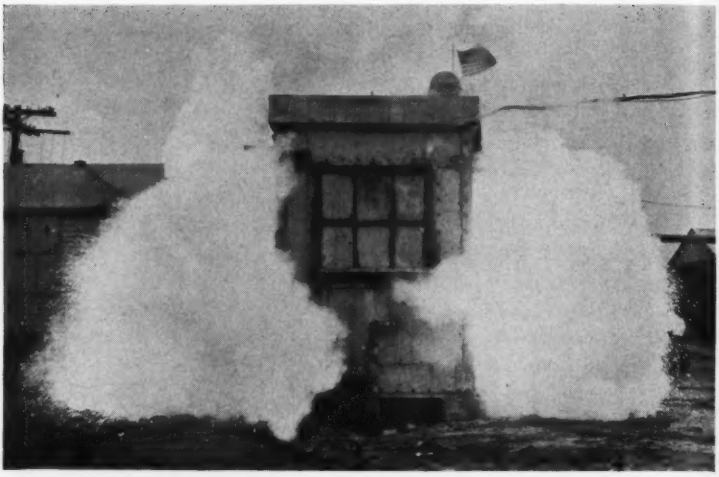
Most fires occurring during machining operations are caused by friction between the tool and the work. This is particularly liable to happen when taking fine finishing cuts at high speed if the tool is dull.

Experience will show the skilled machinist the necessity of keeping the tool sharp on finishing operations.

GRINDING OPERATIONS. Ordinary type dust collectors should not be used for removing magnesium dust. A special dust collecting system should be used which utilizes a water spray nozzle to knock down the dust into a trough where the dust is carried away as a sludge. This is one rare exception to the normal isolation of magnesium from water. Good ventilation should be provided to remove the hydrogen which is formed. The sludge should be collected in drums and frequently disposed of by mixing with about 4 or 5 parts by weight of sand or dirt and burying in a dump. The sludge should not be allowed to stand in the half-wet condition, as a reaction between the magnesium and water might cause the temperature to rise to a point where ignition could occur. The amount of magnesium alloy involved and the hazard connected with the grinding process do not warrant attempts to reclaim magnesium dust. Grinding wheels for use with magnesium and its alloys should not be used for other metals and frequent cleaning around the grinding operation is essential to prevent accumulations of dust. The fire hazard involved in the temporary storage pending disposal of dry grinding dust, floor sweepings, and sawdust may be considerably decreased by wetting this refuse material with a cheap high flash point mineral oil. This material can then be safely disposed of by either burning on a dump or mixing with sand and burying as mentioned above.

FOUNDRIES AND DIE-CASTING. Foundries and die-casting operations using molten magnesium or its alloys should be located in non-combustible fire-resistive buildings where sprinkler protection is unnecessary since automatic sprinklers may actually increase the fire hazard. Foundries should be on the first floor of such buildings and ceilings should be high, so that burning vapors of magnesium will neither damage the ceiling nor "mushroom" and spread the fire. The floor around the melting units and where there is danger of spilling molten metal should be of hard-burned or vitreous paving block.

The furnace settings must be cleaned often enough to keep them free from iron scale. If molten magnesium runs on to hot scale, a thermit reaction may occur, forming iron and magnesium oxide, probably with explosive violence.



Magnesium dust explosions are violent. Shown here is an explosion caused by only two and a half pounds of the material. Left: One and a quarter pounds of powdered magnesium being poured into each of two large open cups. These cups were then attached to the ceiling of the small but strongly constructed house (above). The powdered metal was scattered throughout the house by compressed air and ignited by a gas flame. Bursts of smoke from the resulting explosion are being emitted from standard explosion venting windows. Window in the foreground was secured.

In magnesium melting pots a mixture of sulfur and boric acid should be used to cover the surface of the metal and prevent oxidation and burning of the molten metal. This mixture can also be used in emergency to extinguish small fires.

ANNEALING AND OTHER HEAT-TREATING PROCESSES. The chief precaution to be observed in this operation is to exercise careful control over the equipment to prevent overheating the magnesium alloy by radiation from electric heating elements or brickwork at a temperature higher than the atmosphere within the furnace. Massive pieces will not ignite readily, but thin projections or fine material in a casting constitute a definite hazard, since the burning of these smaller pieces is communicated to the body of the casting.

The heat treating temperatures ordinarily are from 730° F. to 780° F., and at temperatures below the latter figure magnesium alloy castings may be held for long periods without ignition. Ignition has been reported when furnace temperatures have been in excess of 800° F.

STORAGE. Although finely divided magnesium alloy will ignite readily, larger pieces such as castings and billets do not ignite except when heated to about 900° F. for a considerable period of time. Accordingly, although storage of such material should be in a non-combustible building away from other more readily combustible material, storage in an ordinary sprinklered building is reasonably safe because of the probability that any fire in other contents or involving the building construction will be extinguished before there is sufficient heat to ignite the magnesium.

Extinguishers.

The best extinguishing agents for fires in magnesium alloys are powdered talc, fine cast iron borings, or similar inert material. In attempting to extinguish a fire in a large pile of magnesium chips, the extinguishing material should be spread gently over that portion of the material which is burning and unburned magnesium alloy should be carefully shoveled away from the fire area. The fire should then be allowed to burn itself out quietly without disturbing the burning material.

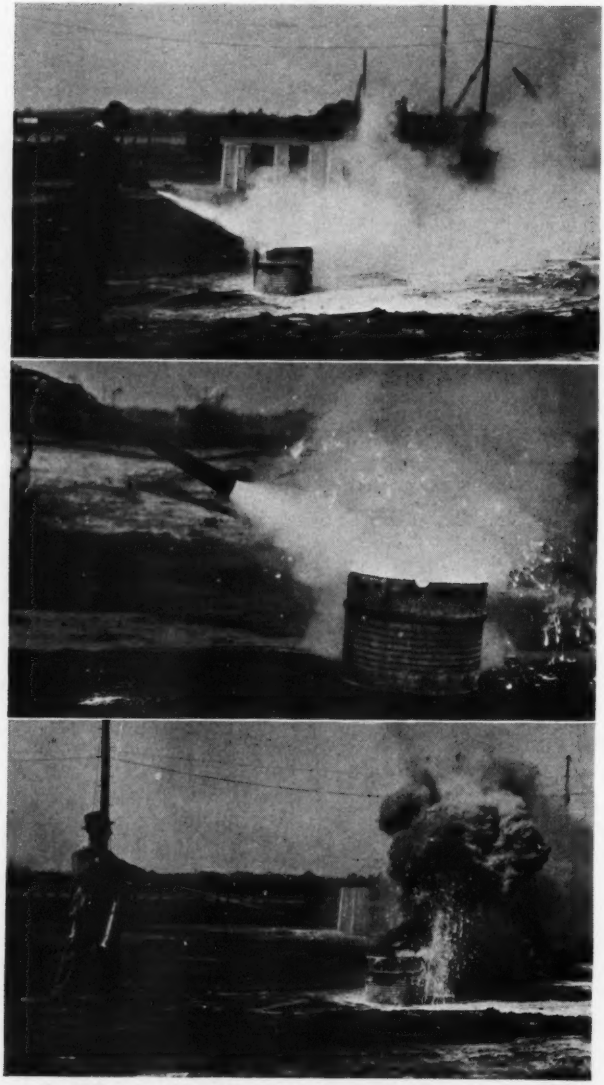
Dry sand and talc have been used with success on magnesium alloy fires, although sand itself is decomposed by burning magnesium as is talc to a lesser degree.

Sand should not be used around machining operations, since complete overhauling of machinery is necessary after the fire to prevent damage by the abrasive particles of the sand.

Wheeled bins containing scoops and one of the above extinguishing agents (except sand) should be located at strategic points around machining operations for use in extinguishing magnesium fires.

Where fire in magnesium alloys has attained considerable size upon arrival of the fire department, in most cases the least hazardous course to follow is to prevent extension of the fire to exposed buildings by the liberal use of hose streams, without allowing any water to come in contact with the burning magnesium. The use of water on buildings where magnesium is stored is dangerous under any conditions, and should only be attempted if it is certain that water will not reach the burning magnesium itself.

A number of so-called "extinguishers" have been tested using materials inert to magnesium, but which in themselves are flammable. These have not been used on fires involving more than a pailful of scrap turnings. Lubricating oil, or mixtures of carbon tetrachloride and lubricating oil are representative of this class and have not proven satisfactory, since it is difficult to apply the mixture to the burning magnesium alloy without causing the oil itself to ignite.



Various types of fire extinguishers being used on burning magnesium. In each case, use of the extinguisher only serves to accelerate the burning. Top: Dry chemical. Center: Carbon dioxide. Bottom: Vaporizing Liquid.

Fire and Explosion Record.

With the increasing use of magnesium alloys, fires and explosions are being reported with increasing frequency. The following summaries include the more important fires and explosions reported, and several which involved only a small loss, but which are of interest as illustrating the importance of proper fire fighting procedure. Several other fires and explosions involving only small losses and similar to those summarized, have not been included in this record.

BLOOMFIELD, N. J., JAN. 25, 1928. Magnesium alloy castings were being turned on a lathe when the cutting tool struck sparks from sand imbedded in the metal. Turnings ignited and opened one sprinkler. The fire burned itself out, with a loss of about $350.

BLOOMFIELD, N. J., JAN. 26, 1934. A cutting tool struck sparks from sand imbedded in a magnesium alloy casting and magnesium turnings ignited. When almost extinguished by talc, a sprinkler operated, washed off the talc and intensified the fire. Water and fire badly damaged the machine. The loss was approximately $500.

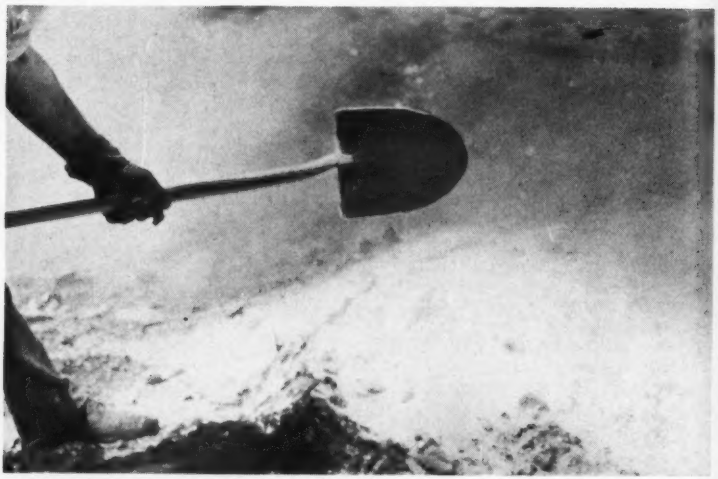
CLEVELAND, OHIO, Sept. 17, 1935. Molten magnesium alloy was about to be poured from a ladle into molds, when the tipping mechanism became deranged and the molten metal flowed onto a concrete floor which probably contained considerable moisture, since the magnesium alloy ignited at once and was finally extinguished with sand only after most of the metal was consumed. The loss was approximately $110. A factor in the low loss was a high, non-combustible roof in the foundry building which was not damaged by the heat from the burning magnesium.

PITTSBURGH, PENNA., DEC. 16, 1937. Magnesium alloy billets ¼ in. and 1 in. in thickness were being heated to 990° F. prior to rolling. Ignition of the billets occurred, causing damage of $400 to the furnace.

PITTSBURGH, PENNA., FEB. 1, 1939. A small fire occurred during the sawing of a magnesium bar. The saw and motor had to be dismantled to remove sand used in extinguishing the fire.

EAST RUTHERFORD, N. J., FEB. 9, 1939. A cutting tool came in contact with a steel wedge used to secure a magnesium alloy casting in a milling machine. The sparks ignited the chips on the bedplate. Although sand was used in an attempt to extinguished the fire a sprinkler head opened and intensified the fire in the considerable quantity of chips. The loss of $600 was largely due to the labor cost of removal of sand from the milling machine.

BATAVIA, N. Y., FEB. 15, 1939. In a plant engaged in die-casting of magnesium alloy, scrap was being reclaimed in a large gas-heated pot located in a small corrugated iron on steel frame building. Some of the scrap was wet and the pot was being heated slowly to drive off moisture. The heat caused a rapid reaction between the magnesium and water and an "explosion" resulted which burned two men fatally. The public fire department responded and extinguished the fire by shoveling cast iron chips on to the burning magnesium alloy, although most of the charge had been consumed before they arrived. The property loss was about $300.



Burning magnesium can be extinguished by covering it with powdered talc. The talc should not be removed until the magnesium is cool, otherwise upon contact with the oxygen of the air the metal may reignite.

PITTSBURGH, PENNA., DEC. 20, 1939. Magnesium sawdust was ignited by sparks from a welding torch. The fire was extinguished by the use of talc with a loss of only $65.

HARTFORD, CONN., JAN. 31, 1940. Twenty-five hundred pounds of magnesium alloy turnings in wooden barrels and boxes with burlap covers, together with large amounts of aluminum and brass turnings, were stored in wooden sheds. One shed became ignited and the fire spread to the magnesium. The public fire department was called and although they were cautioned about the use of water on magnesium, several large hose streams were applied to the buildings involved in the fire. Water coming in contact with the magnesium resulted in an explosion of the rapidly burning material, causing a shower of burning magnesium and an increase in the intensity of the fire, which ultimately resulted in the destruction of four wooden buildings. The loss was approximately $7000.

HOUNSLOW, ENGLAND, FEB. 14, 1940. A fire started in a storage shed containing 15 tons of magnesium scrap and spread to several other wooden sheds and a brick building containing over 200 tons of aluminum scrap. This fire occurred in a small town in England and burned for over 48 hours, because the fire was spread by explosive reactions caused by playing more than 20 hose streams on the burning magnesium and aluminum. Two near-by dwellings were destroyed by the explosions. Apparently the danger of using water on magnesium fires was not realized by the local fire brigade. Fourteen members of the brigade were injured.

YONKERS, N. Y., JUNE 12, 1940. A magnesium alloy pulley was being turned on a lathe when turnings became ignited by friction. Vaporizing liquid extinguishers which were used only intensified the fire, which finally burned itself out. The loss was $30.

CLEVELAND, OHIO, JULY 28, 1940. A large electrically-heated furnace with a recirculating fan was being used for the heat treatment of 5300 lbs. of castings of 88% magnesium alloy. The temperature was said to be 800° F. and iron pyrites were placed in the furnace to form a sulfur dioxide atmosphere. The castings ignited after being in the furnace for 21 hours and were completely consumed even though sand was piled around all openings. The heat melted some of the fire brick and the arch and one wall collapsed. The property loss was about $18,000.

PATERSON, N. J., SEPT. 9, 1940. Fifteen hundred pounds of magnesium alloy turnings in a scrap metal yard were stored in burlap bags in wooden bins in a one-story cement block building with joisted floors and roof. The dealer had not previously handled this type of scrap and was probably unfamiliar with its fire hazard. The fire department used a hose stream without knowing the fire was in magnesium alloy and several firemen were badly burned by the resulting flash. Thereafter the hose streams were directed only on other combustible material, although an unsuccessful attempt was made to extinguish the fire by the use of a spray nozzle. A load of sand was obtained, but it was damp and the scrap continued to burn beneath the layer of sand. The loss was about $300.

Magnesium Dust Explosions.

NEW YORK, N. Y., JULY 18, 1922. Magnesium powder was stored in part metal and part waterproof paper-lined cases in a general warehouse. The cases were being removed when ignition of the powder was caused by friction or a spark from a handling hook. Several minor explosions occurred and when a hose stream was applied it had no effect on the fire. It appears that this may not have been a true dust explosion, but an explosion of flashlight powder. One man was killed and 20 injured in fighting this fire. The property loss was $1,000,000.

NIAGARA FALLS, N. Y., FEB. 16, 1926. Magnesium dust was being screened after manufacture in a ball mill. Ignition from an unknown source caused an explosion which damaged the equipment and the building. The loss was approximately $3500.

CLEVELAND, OHIO, FEB. 20, 1930. Dust from the grinding of magnesium alloy castings was wet by spray only after it had passed through about 40 ft. of duct instead of having the water spray close to the grinding wheel. A casting had been made, using a wire nail to hold the core upright. When the riser was ground off, sparks from the wire nail ignited the dust and caused an explosion which ruptured the ducts, air washer, and fan housing, and broke about 200 lights of glass. The loss was $800.

Acknowledgment.

The General Electric Company, Lynn, Mass., coöperated with the Factory Mutual Laboratories by supplying material for fire tests and by supplying information on machining experience with magnesium alloys. The Dow Chemical Co., Midland, Michigan, also assisted by contributing their experience with magnesium alloys with respect to fire hazard, extinguishing agents and foundry practice.

Baltimore Cork Yard Fire.

One of the worst fires in Baltimore, Maryland, since the great conflagration of 1904 occurred on the afternoon of September 17, 1940, when the nine-acre cork storage yard of the Crown Cork and Seal Co., Inc., was destroyed by fire. Ten thousand tons of cork constituting a year's supply for the plant was destroyed. Loss to the cork was placed at $780,000. Additional damage including the destruction of two sprinklered storage buildings, loss of nine railroad box cars, and other damage bring the total loss near the million mark. The main grinding plant of the cork company valued at another million dollars was seriously exposed during the fire and was saved by the efforts of some 450 firemen who responded to a total of fifteen alarms with some sixty pieces of apparatus.

Property Involved.

The plant at which the fire occurred is a large bottle cap and cork specialty factory. The fire involved some ten thousand tons or 150,000 bales of cork in the storage yard and warehouses of the plant. The bales averaged about one hundred and fifty pounds in weight and while varying in size measured about two and one-half feet in each dimension. The cork involved is classed as "waste" cork, consisting of irregular sized pieces or sheets of the material about one and one-half inches thick and several inches long. The individual bales are bound by baling wire and strap iron and have slats or sticks to hold the material in place. Cork is so light that the flying brand hazard is unusually high and a fire involving baled cork may be compared with a fire in tan bark or kindling wood similarly arranged. Once a fire is well started in large piles of baled cork it will continue with intense heat inside the pile regardless of generous applications of water on the outside of the pile unless the pile is pulled apart.

The bales were stored in numerous piles, covering areas of fifty by forty feet and thirty feet in height. Due to congestion in the yard, clearances between piles were only about three feet wide in some places, making the entire nine-acre tract one fire area.

Also destroyed by the fire were two large sprinklered cork storage buildings divided by brick fire walls and housing some thirty to forty per cent of the total cork storage involved in the fire. These buildings were built some eight or ten years ago. At the time they were built it was intended that adequate

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NOTE: This account is based upon data furnished by the Eastern Underwriters Inspection Bureau (member N.F.P.A.); Chief Howard Travers, Baltimore Fire Department (member N.F.P.A.); and other sources.

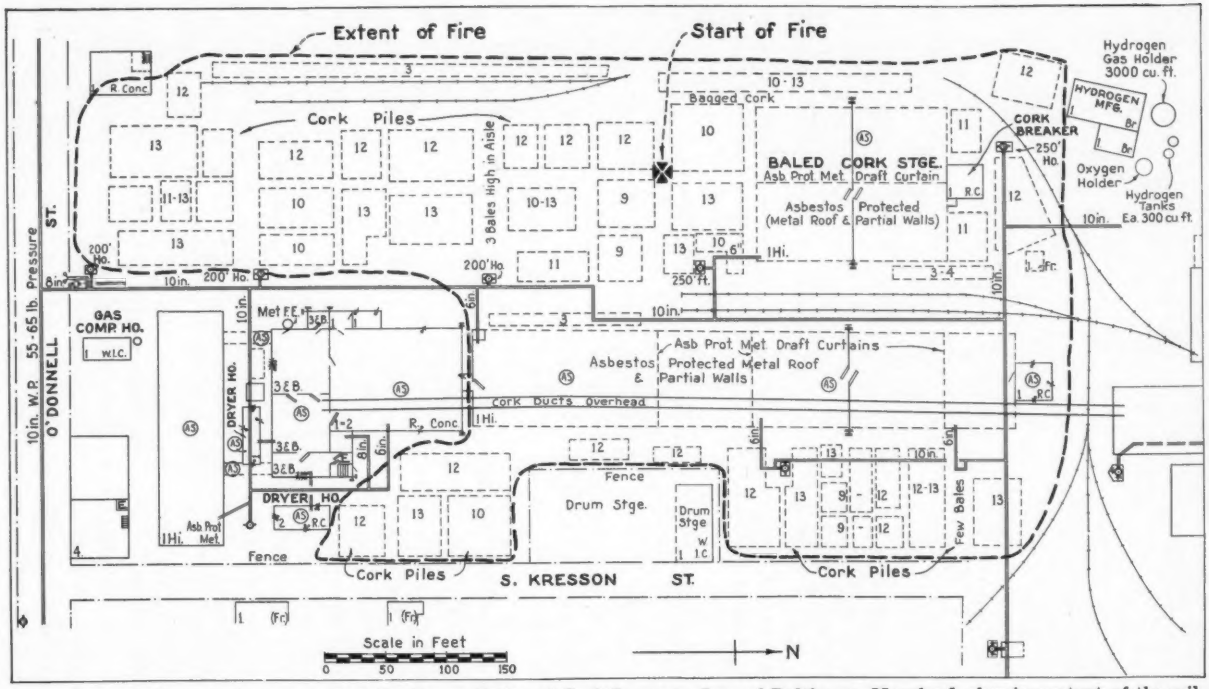
International.

One hundred fifty thousand bales of cork were destroyed in this fire at the Baltimore, Maryland, plant of the Crown Cork and Seal Co., Inc., on September 17, 1940.

clear space would be maintained between these buildings and any open cork storage. A few months after they were built, however, the plant management used the space around the buildings for the storage of larger incoming shipments. The result was that the hazard of unprotected cork storage formed a serious exposure against the sprinklered cork storage sheds. The exposure was unusually serious because the storage sheds had partly open sides for ventilating purposes. These cork storage buildings were of one-story steel and "asbestos protected" construction with corrugated iron roofs. Fire walls bisecting the sheds were of little protection against the yard exposure. Plant buildings had plain glass windows and lacked fire shutters.

Manufacturing operations at the main plant were dependent upon the stock in the storage yard. About one thousand tons of stock were used each month. Fortunately, five hundred tons of stock in another storage area escaped the fire. Sufficient ground-up stock was on hand after the fire to permit a continuance of manufacturing until grinding could be resumed on the remaining stock. Before this stock becomes exhausted arrival of cargoes afloat should provide sufficient stock for continued operations. Grinding operations were interrupted because it was necessary to severely wet down the exposed grinding plant during the fire.

It is reported that the storage in the yard of a supply of cork adequate for a year's operations was a precautionary measure against the possibility that the supply from Spain and Portugal might be cut off by the war. The cork supplies at the plant are said to have been included in a recent government defense survey because cork is used in the manufacture of ammunition.



Plan of the cork storage yard of the Crown Cork and Seal Company, Inc., of Baltimore, Maryland, showing extent of the million dollar fire of September 17, 1940. Numbers shown on cork piles indicate height in bales.

Story of the Fire.

The fire started at the southern end of the storage area that extended for more than a block. It originated in a pile of baled cork stored in the open. The source of ignition is unknown, but the fire started near a railroad siding. It is attributed to a smouldering spark from an unknown source.

Employees cutting grass near by discovered the fire and attempted to extinguish it with private equipment, including four private hose streams. The plant had no organized private fire brigade. When the employees found that the fire was beyond their control they operated several central station boxes. Before that time a city fire alarm box was sounded by an employee of a near-by plant of the Standard Oil Company.

The first alarm was received by the fire department at 2:35 P.M., and was answered by three engine companies, one ladder company, and one chemical company under the command of a battalion chief. Immediately upon arrival the battalion chief sounded third and fifth alarms, calling thirteen additional engine companies, three more ladder companies, the chief of department, a deputy chief and three battalion chiefs. Five minutes later a sixth alarm was sounded, calling out three more engines. These initial calls were followed during a period of slightly more than two hours by nine more alarms, bringing the total fire department response to forty-five engine companies, eleven ladder companies, one chemical company, one water tower, and twelve chief officers. To obtain a better distribution of apparatus around the large fire area these nine subsequent calls were sounded from two boxes at different locations.

In spite of the great concentration of apparatus at the fire the remainder of the city was well protected. Seventeen engine companies, fifteen ladder companies, five high pressure companies and three chemical companies were not called to the fire. These were soon augmented by seventeen reserve engine companies, six reserve ladder companies and a reserve chemical company. These reserve companies were formed from members of the off-shift called back by radio appeals. These companies utilized the fully equipped "second line" apparatus maintained by the department. Three of the reserve companies went into service at the fire on the later calls.

When the first firemen arrived it is said that five large piles of cork were burning. The fire department made every effort to confine the fire, but due to existing conditions it was impossible to bring it under control before the entire storage area and the two storage sheds were involved. The first attack on the fire was concentrated largely on the southerly side of the storage area, but hose streams were ineffectual in checking the progress of the fire in the burning piles. The fire spread by direct flames and flying brands, which ignited the cork piles on the east side of the long sprinklered storage building in the center of the yard even before the building itself ignited. Plant employees first noticed this new fire and attempted to combat it while fire department

streams were being brought to the east side of the yard, but the fire soon became so general and so intense that private and public fire department efforts were successful only in the defense of some of the exposed buildings. The large warehouse, some 455 feet long, was exposed on both sides and was entirely destroyed in spite of attempts to protect it with hose streams. The fire was intense throughout practically the entire fire area for a period of several hours. Operators of apparatus arriving on additional alarms reported that hydrant pressures were low. This was attributed to the fact that the plant engineer had ordered plant employees to knock open all sprinkler heads in various storage sheds not involved in the fire. The fire department reports that some four hundred or more heads were thus opened and estimates that ten thousand gallons of water per minute were wasted thereby.

At the south end of the plant the comparatively new cork grinding building, constructed at a cost of about one million dollars for building and equipment, was under severe exposure for some hours. Much of the fire department's efforts were concentrated on saving this unit. When originally constructed it was but mildly exposed, but again the crowding of cork piles had caused considerable exposure. This building was of fire-resistive construction, one to three stories in height. It was shielded by a fire wall on the north end against exposure from the long cork storage building. Fortunately it was saved without appreciable damage by fire, but water damage was done to motors and equipment. An extensive battery of ducts for blowing ground cork to the main plant was destroyed. This damage caused about two weeks interruption to plant operations.

In controlling the fire, the fire department used some fifty hose streams, including deck pipes operated by companies in the storage yard. Other hose streams completely surrounded the fire. Water supplies were from hydrants on sixteen-inch mains on streets surrounding the plant. Three connections from these mains supplied a ten-inch yard main system for sprinklers and hydrants. However, numerous long leads of hose were necessary in fighting the fire and in some cases three pumpers were required for a single relay. Due to the rapid spread of the fire the fire department lost twenty-five hundred feet of hose, several ladders and other equipment. During the height of the fire with fire department pumpers in operation, pressures on the public mains fell to five pounds, where they remained until the next day, when it became possible to shut off some of the connections to the sprinkler equipments that were bleeding the system. The fire was brought under control about 9 P.M. on the same day.

During the fire twenty-three firemen were listed as injured and fifty others received first aid treatment. Many of the injuries consisted of eyes burned by the intense heat.

After the blaze, inability to close valves controlling sprinkler equipments in the destroyed storage sheds made it necessary to shut off part of the loop

International.

Firemen responded to fifteen alarms and used some fifty hose streams in attempting to control this blaze, which caused approximately one million dollars loss in a cork storage yard at Baltimore, Maryland.

system, thus depriving sprinklers in two other buildings of water. Other sprinkler equipments in the plant were supplied by two connections from the city water system at fifty-five pounds pressure. After the fire the 75,000-gallon gravity tank supplying sprinklers and the 200,000 gallon suction tank for the two 1000-gallon fire pumps were empty.

In addition to the loss to the Crown Cork and Seal Co., Inc., nine Pennsylvania Railroad box cars being unloaded from a siding at the yard were destroyed before a switching engine could be sent to move them. A wooden shed owned by the near-by Cambridge Iron and Metal Company and a wooden fence at the City Cooperage Company plant were damaged. The private fire brigade at the Standard Oil Company plant across the street from the fire was on duty throughout the night. At the height of the fire the tanks at the plant were wet down to keep them cool and protect them from sparks.

This blaze was by no means the first fire to occur at the Baltimore plant of the Crown Cork and Seal Company. N.F.P.A. fire record files showed that thirty-eight other fires have occurred at this plant during the past ten years. These included a four-alarm fire following an explosion in the cork grinding building on August 8, 1939, and a two-alarm fire during November, 1933. Most of the various fires were controlled by sprinklers or were extinguished before sprinklers operated.

Conclusions.

This fire illustrates the importance of adequate private protection and proper storage for unusual concentrations of combustible stocks, such as are

likely to result from wartime restrictions to trade. The plant management's foresight in having on hand a year's supply of cork apparently did not extend to include appreciation of the dangers of fire at home. With ability to secure replacement of stock in doubt, the fundamental fire safety rule of limiting fire areas by adequate subdivision should have been a minimum precaution. Clearances of only a few feet made the entire storage yard a single fire area. Had proper clearances been maintained it is likely that the fire would have been confined to a single pile of cork. The storage sheds might also have been saved by proper fire breaks. Additional safety would have been obtained by providing sprinklered storage buildings, subdivided by adequate fire walls, for the entire stock.

This fire also illustrates the fact that the practice of knocking open large numbers of sprinkler heads in advance of a fire may have an adverse effect upon fire extinguishment due to wastage of water and reduced pressures.

Rail Car Holocaust.

One of the worst railroad disasters in recent years occurred at Cuyahoga Falls, Ohio, on the evening of July 31, 1940, when flames enveloped a gas-electric passenger coach after it had collided head-on with a freight train. Forty-three persons lost their lives in the flaming wreckage.

The accident occurred at 6:00 P.M. during clear weather, when Pennsylvania Railroad gas-electric car No. 4648, running between Hudson and Akron, Ohio as train No. 3380, collided with Pennsylvania freight train FC-4, consisting of seventy-three cars drawn by two locomotives. The gas-electric car had just rounded a curve and was said to have been traveling about twenty-five miles per hour and the freight train was moving at a speed of from twenty to twenty-five miles per hour when the accident occurred.

The gas-electric car was operating with its engine compartment in the rear. The impact of the collision caused the car to telescope and split open, dislodging and driving both of its trucks forward against the locomotive, with the body of the car dropping to the rails. In this position the car was shoved backwards about five hundred feet, where both trains came to rest with the lead locomotive imbedded in the car. The freight train was not derailed.

With the impact, the rear truck of the gas-electric car ruptured the fuel tank containing 150 gallons of gasoline. The gasoline ignited, involving in flames the gas-electric car and lead locomotive of the freight train, trapping the occupants of the gas-electric car. The engineman and conductor of the passenger coach leaped to safety, but were severely injured. Four other railroad trainmen who escaped with injuries included one who was riding home from work on the gas-electric car, and three members of the crews of the freight locomotives who were less seriously injured.

International.

Forty-three persons lost their lives in the flaming wreckage of a gas-electric rail coach after it collided with a freight train on the Pennsylvania Railroad near Cuyahoga Falls, Ohio, on the evening of July 31, 1940.

When the fire department arrived the wreckage was enveloped in flames. The fire was fought with hose streams for about twenty-five minutes before the bodies of the victims could be moved. Of the forty-three killed, twenty-five were pay passengers and others were railroad employees "deadheading" home from work.

According to railroad officials, the responsibility for the accident rests entirely upon the conductor and enginemen of the gas-electric car in ignoring an order directing them to stop and take a siding to permit the northbound freight from Columbus to pass. The Interstate Commerce Commission in a subsequent investigation suggested the possibility that carbon monoxide in slight concentration may have dulled the faculties of the gasoline rail car crew, but with the engine compartment in the rear it is difficult to understand how men in the front of the car would have been affected.

St. Louis R.R. Signal Tower Fire.

The destruction by fire on July 22, 1940, of the main track signal and switch control tower handling the entire switching facilities for the Union Station at St. Louis, Missouri, brings out the often expressed necessity of adopting the best structural design and fire protection facilities in order to safeguard equipment vital to essential operations.

The main factors contributing to the total loss of this control tower were: combustible construction, arrangement conducive to the rapid spread of the fire, failure of private protection, inaccessibility and delay in bringing the public fire apparatus into operation.

The fire occurred from an unknown cause about 4:50 P.M. in Central Tower No. 1, situated about 750 feet south of the train shed of the St. Louis Union Station. In addition to controlling the switching equipment for the movement of all trains in and out of the station, it controlled switching equipment in its vicinity and in the yard of the Missouri Pacific Railroad adjoining the terminal to the south.

While insurance carried on the tower was $33,500, cost of replacement is estimated at $250,000. The cost of extra switchmen for hand switching, made necessary by the loss of the tower, is about $300 each twenty-four hours. During the estimated three months required to replace the tower, the extra cost of hand switching may add $27,000 to the loss. Curtailment of suburban train service and other interference with railroad operations added further to the indirect loss.

Description of Tower.

The signal tower destroyed by the fire was one of a series of towers handling yard and station traffic. It contained an interlocking switch and an interlocking switch and signal control board handling equipment of the entire forty-one track terminal passenger station. Switches were operated by compressed air admitted to the mechanism by electrically operated valves controlled in the signal tower. Insulated wires carrying a maximum of eighteen volts extended from the control board in the second story to the basement of the tower and passed to wood covered depressed areas at sides of the tower. Current supply was from storage batteries floating on the direct current side of a motor generator set.

The tower was erected in 1903 and was largely of combustible materials. Basement walls were of concrete and the walls of the first floor were of

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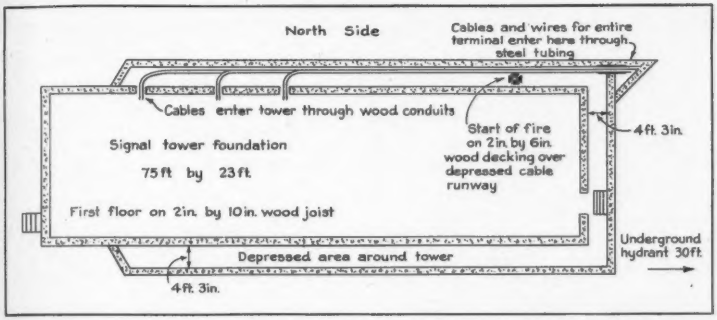
NOTE: This account of the St. Louis terminal signal tower fire is based upon a report by the Missouri Inspection Bureau (member N.F.P.A.), and a report by Inspector William Hoffschwelle, and Chief Lawrence C. Cornoyer, of the St. Louis Fire Department.


North Side
Cables and wires for entire terminal enter here through steel tubing
Cables enter tower through wood conduits
Signal tower foundation
75 ft by 23 ft
Start of fire on 2 in. by 6 in. wood decking over depressed cable runway
4 ft. 3 in.
First floor on 2 in. by 10 in. wood joist
Underground hydrant 30 ft.
Depressed area around tower
4 ft. 3 in.

brick masonry with considerable limestone trim. The second floor was glass enclosed from floor to ceiling, the glass being set in between turned wood columns resting on the masonry walls of the first story. These columns formed the support for the ceiling joists of the second floor and the tile roof. At each corner of the building, an angle iron which rested on brick masonry walls continued up to the height of the second floor ceiling and tied into the framework of the roof structure. Wooden joists, wooden floors and ceilings, wooden partitions, wooden lockers, wooden conduits, and wooden sheathing contributed to the combustibility of the building.

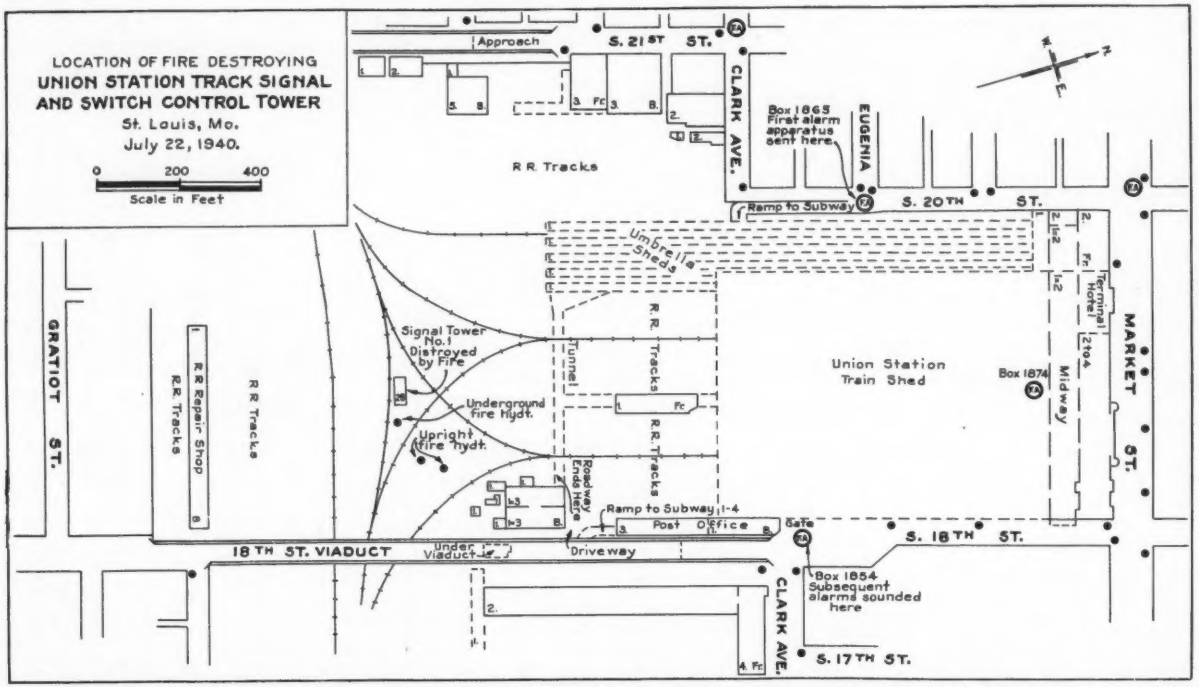
The first floor contained batteries and motor generator sets and was also used as a repair shop. The second story contained the control board and was accessible only by an open inside stairway of wooden construction. The basement was used as a shop for the switch and signal repair crew.

Story of the Fire.

The fire was discovered by an assistant train dispatcher, who saw it through a window in the northeast corner of the washroom about 4:49 P.M. He immediately notified two men on the operating floor of the tower, directing them to call the fire department. Instead, the operators called the station master, who dispatched a crew of railroad employees to the fire.

Due to the rapid spread of the fire, the station master called the fire alarm office at 4:56 P.M., stating that the tower was on fire, and instructed the fire alarm operator to send the department to 20th and Eugenia Streets. This location was about 1200 feet air-line distance from the fire. In answer to this call, Engine Co. 10 and Ladder Co. 8 were dispatched. This is a normal response to a still alarm in St. Louis.

Immediately upon arrival, the lieutenant in charge of the engine company discovered that the fire was closer to the 18th Street side of the yard. He took his company through the subway of the Union Station and proceeded to go into service from that point. He then called for more help and the box at 20th and Eugenia Streets was sounded at 5:03 P.M., bringing three more engine



Plan showing the location of Signal Tower No. 1 in the yard of the St. Louis Union Station terminal. The distance of the fire alarm boxes from the tower, and the location of the tower within a maze of railroad tracks remote from public hydrants, explain in large part the delays in getting fire department hose streams into operation.

companies. These companies also took the subway to the 18th Street side of the terminal. Shortly after this box was struck the captain of the ladder company went to the power house to call for more companies. He asked the operator on duty to connect him with the fire alarm office. She informed him that she would connect him with the station master. He explained that he wanted to call more companies to the tower fire. After some explanation, the operator finally made the connection and the fire alarm office sounded the box at 18th and Clark Avenue at 5:09 P.M. This was followed by a second alarm at 5:14 P.M. from this box which was at the most strategic point for fighting the fire.

The total response to the various calls included thirteen engine companies, three ladder companies, one squad wagon and two district chiefs, under the command of Chief L. C. Cornoyer.

When the station master dispatched his crew to the fire they immediately proceeded to fight the fire with private fire appliances. Rapid spread of the fire had made use of any inside fire fighting equipment impossible. The fire spread so quickly that the two operators on the second floor of the tower could not use the stairway and had to escape over an outside wooden ladder. The railroad employees attached two sections of 2½-inch hose to an underground hydrant thirty feet distant, but the operating stem of this hydrant broke when they tried to turn on the water. Attempts to use two other private hydrants 130 to 150 feet distant were unsuccessful because adapters were not available to reduce the 4½-inch openings to fit the 2½-inch hose. Reports that these hydrants were inoperative were disproven by the fact that one of them was used by a fire department pumper during the night and because both of them were tested by the fire department the next day and were found satisfactory.

It is probable that the equipment in the tower was already severely damaged before the fire department was able to get water on the fire. Traffic in streets and viaducts in the vicinity of the station was approaching the usual maximum evening peak. The tower was situated in a maze of railroad tracks at a considerable distance from public streets and was not readily accessible. There were no roadways provided for pumpers to reach the private hydrants in the terminal yards. All of the hose used by the department had to be carried by the firemen and laid by hand. All lines were from 900 to 1500 feet in length and were connected to pumpers on the 18th Street side and also from the 18th Street bridge.

Cause and Result.

The entire second floor housing the switch locking machine was destroyed as was most of the first floor. The entire north brick wall collapsed and fell outward. A near-by steel semaphore bridge was damaged. The total loss, including the indirect losses previously mentioned, was between $250,000 and $300,000.

alarm boxes from the tower, and the location of the tower within a maze of railroad tracks remote from public hydrants, explain in large part the delays in getting fire department hose streams into operation.

The cause of the fire was undetermined. The suggestion that a short circuit caused the fire seems a rather remote possibility, since the 110 voltage lighting system in the tower was properly fused and if it had been the cause it would have put the lighting system out of operation. If a short circuit had occurred in the low voltage system it should have put the locking machines out of service immediately, whereas, the operators were switching and locking switches after the fire was discovered.

Conclusions.

This fire shows the results of housing vital and costly equipment in a building of combustible construction without suitable cut-offs to prevent the spread of fire. Fire-resistive construction and limitation of the occupancy to the control equipment and eliminating shop, storage or other combustible occupancy from the building would minimize the probability of any such extensive fire damage.

This fire also shows the fallacy of depending upon public fire protection without providing adequate facilities for calling the fire department, for access to a burning building and for convenient water supplies. The fire department was greatly handicapped in doing any effective work because of the location of the building in the midst of a maze of railroad tracks with no adequate roadways, making it necessary to carry hose lines long distances by hand, with consequent delays in fire fighting. The practice of providing only a minimum response of apparatus to telephone alarms has been criticized in connection with this fire, though in the present instance, owing to the difficulty of access, it is not clear that even if the first alarm response had been greater, additional man power and equipment could have been put into effect quickly enough to have any great effect upon the fire damage.

Lack of training and equipment of the private fire fighting forces apparently prevented effective work by the railroad men. An organized, properly trained private fire brigade might have been of considerable value prior to the arrival of the fire department. However, the main lesson of this fire seems to be that the construction and arrangement of the building and equipment should be so planned for fire safety that it would not be necessary to place primary reliance on any manual fire fighting operations.

Fires and Fire Losses Classified, 1939.

Continuing the practice begun three years ago of showing the distribution of the annual fire loss in the United States by cause and occupancy classes, the N.F.P.A. Department of Fire Record presents the following tables covering the year 1939. Experience of the past years shows that these estimates are widely used in fire prevention and fire protection work.

The data upon which these tables are based were obtained from fifteen state fire marshals' reports for 1939, or the closest fiscal year thereto. Reports of these particular states were chosen because they contained the most complete classifications. While methods of reporting and tabulating fire loss figures are different in each state, it is believed that the volume of statistics from the fifteen typical states included herein is sufficiently large to indicate the relative distribution of fires and fire losses for the various occupancies and causes.

Tables I to IV are tabulations made from fire marshals' reports. Table I shows the number of fires, and Table II shows the fire loss by occupancies reported for the year 1939 in the fifteen states. Tables III and IV show the number of fires and fire losses distributed according to causes. The general classes making up both the occupancy and cause classifications were carefully chosen with regard to good practice and to classes most commonly used in the reports. Tables V to VII are recapitulations and estimates for the entire United States based upon the first four tables and adding a certain percentage to cover unreported fires and losses as explained below.

Table V is a recapitulation of the state totals presented in the foregoing tables, with columns added to show the number of fires per thousand population and the fire loss per capita. It will be observed that a total of 104,424 fires were reported in 1939 for the group of fifteen states having a total population of 39,969,731 in the 1940 U. S. census. A study of the best data available indicates that this number of fires is approximately half the actual number of fires for the year, and therefore 100 per cent has been added to get the estimate for the fifteen states. When the resulting figure is applied to the whole country at the population ratio, the estimated number of fires in the United States in 1939 is 685,000. This makes 5.24 fires per thousand population as compared with 5.14 in 1938 (October, 1939, QUARTERLY, page 137).

The estimated total fire loss of $300,000,000 in the United States in 1939 was obtained by applying the population ratio to the total loss in the fifteen states and adding 25 per cent to cover unreported losses. This figure is $35,000,000 more than the corresponding figure for 1938.

NOTE: Canadian fire loss information for the year 1939 was published in the July, 1940, QUARTERLY, page 60.

Table 1. Number of Fires by Occupancies in Fifteen States — 1939.

Occupancy	Illinois	Indiana†	Iowa	Kansas	Louisiana	Massachusetts	Nebraska	North Dakota	Ohio	Oregon*	South Dakota	Vermont	Washington	West Virginia	Wisconsin	Total
I. Public Buildings																
Government buildings	1	6	....	5	9*h*	44	6	16	....	19	3	7	1	....	14	131
Hospitals, institutions	12	5	4	....	....	22	....	....	13	....	2	3	11	1	20	93
Schools	84	26	34	20	33	32	13	40	58	33	6	14	19	7	75	494
Churches	83	23	22	17	13	38	10	8	106	12	7	9	16	5	54	423
Theatres	23	10	11	7	14	11	4	12	18	15	11	5	11	5	30	187
Amusements, halls	69	17	23	....	....	90	13	....	99	....	6	17	36	1	57	428
II. Dwelling Occupancies																
Hotels, boarding houses	355	17	20	11	51	197	14	55	127	267	36*l*	21	207	7	206	1,591
Apartments, rooming houses	1,995	39	120	....	....	....	33	....	1,653	....	9	....	366	15	163	4,393
Dwellings	6,097	2,528	2,743	1,763*a*	2,176	5,233	972	823	12,353	4,700	382	1,394	3,159	316	9,858	54,497
III. Mercantiles																
Office bldgs., including banks	149	53	37	....	....	200	28	....	162	....	8	6	44	10	86	783
Restaurants, taverns	258	43	95	....	....	115	44	....	241	65	....	3	97	11	372	1,344
Barber, beauty shops	27	....	12	....	....	11	11	....	30	....	2	2	20	....	22	137
Misc. mercantiles	1,334	245	205	439*b*	334*b*	1,061	129	283*b*	1,644	493*b*	120*m*	175	422	49	818	7,751
Warehouses	97	76	110	....	21	186	49	7	242	43	....	9	71	10	92	1,013
IV. Manufacturing																
Metal workers	41	7	13	4	5	28	....	....	3	22	2	3	19	....	48	195
Woodworkers	7	....	6	4	17	10	....	....	....	88	....	13	54	....	9	208
Flour mills, elevators	109	14	13	8	1	....	39	39	....	15	5	1	10	....	47	301
Packing plants, stockyards	....	5	9	....	....	....	....	....	18	....	1	....	10	....	....	43
Bakeries	39	12	19	15*c*	....	14	....	....	36	....	....	1	12	....	12	160
Laundries	42	6	7	12*d*	20*d*	23	11	....	22	....	1*d*	....	11	....	8	163
Cleaners, tailors	25	6	5	....	....	9	....	....	29	....	....	....	3	1	31	109
Misc. manufacturing	353	64	59	16	97	414	26	19	756	153	5	14	289	12	265	2,542
V. Miscellaneous																
Barns	685	363	389	568*e*	156*i*	292	189	333*i*	559	371*k*	123*k*	669*e*	94	35	640	5,466
Outbuildings	1,275	198	218	....	....	158	187	....	772	....	....	14	78	17	817	3,734
Lumber yards	17	18	10	6	8	17	6	....	14	....	6	....	9	3	18	132
Railroads, wharves	106	12	19	15	14*j*	146	....	4	126	32	6	2	....	....	109	591
Bulk oil storage, refineries	85	3	2	26*f*	....	....	....	27	....	15	1	....	1	....	....	160
Garages, filling stations	1,245	200	349	9*g*	16	300	217	25	2,085	31	71	34	120	21	425	5,148
Power plants, pump houses	15	15	12	....	....	5	....	....	....	....	3	22	3	....	68	143
Creameries, dairies	....	10	5	....	....	....	....	....	....	....	7	5	6	....	22	55
Miscellaneous buildings	487	21	293	26	38	51	82	57	948	53	4	6	19	2	79	2,166
Motor vehicles, inc. aircraft	1,671	215	475	266	237	921	181	3	2,781	444	74	....	....	6	1,970	9,244
Outdoor fires	331	53	70	....	....	17	....	....	....	....	19	2	2	....	70	564

*Number insurance claims, not number of fires.
†Fiscal year ending June 30, 1939.

a. Does not include farm dwellings.
b. Includes office buildings.
c. Includes all food products.
d. Includes cleaners.
e. Includes all farm property.
f. Includes retail filling stations.
g. Includes hangars.
h. Includes hospitals and institutions.
i. Includes outdoor fires.
j. Includes power and pump houses.
k. Includes outbuildings.
l. Includes restaurants.
m. Includes warehouses.

†Fiscal year ending June 30, 1939.

*Insurance losses only.
†Fiscal year ending June 30, 1939.

a. Does not include farm dwellings.
b. Includes office buildings.
c. Includes all food products.
d. Includes cleaners.
e. Includes all farm property.
f. Includes retail filling stations.
g. Includes hangars.
h. Includes hospitals and institutions.
i. Includes outdoor fires.
j. Includes power and pump houses.
k. Includes outbuildings.
l. Includes restaurants.
m. Includes warehouses.

Table II. Fire Loss by Occupancies in Fifteen States — 1939.

Occupancy	Illinois	Indiana†	Iowa	Kansas	Louisiana	Massachusetts	Nebraska	North Dakota	Ohio	Oregon	South Dakota	Vermont	Washington*	West Virginia	Wisconsin	Total
I. Public Buildings																
Government buildings	$8	$240	....	$2,300	$1,426h	$38,021	$2,983	$47,429	....	$18,723	$287	$5,465	$135	....	$3,360	$120,377
Hospitals, institutions	3,875	3,388	$285	....	....	38,224	....	....	$9,180	....	58	250	1,358	$15,000	1,501	73,119
Schools	862,840	278,333	120,409	32,760	87,234	118,283	50,029	101,607	62,057	172,824	11,354	6,323	92,404	13,470	47,127	2,057,054
Churches	243,108	62,124	98,834	104,167	10,531	117,008	6,259	548	172,345	3,475	26,974	347	16,264	12,800	71,509	946,293
Theatres	94,421	25,894	16,399	127,924	22,204	75,804	9,315	2,396	12,198	4,738	9,350	100,351	3,792	177,385	4,089	686,260
Amusements, halls	69,784	42,008	43,167	....	....	191,033	36,104	....	104,960	....	11,211	12,703	21,347	18,000	27,986	578,303
II. Dwelling Occupancies																
Hotels, boarding houses	56,202	86,912	44,961	8,813	36,916	178,070	3,523	46,094	42,075	60,807	21,157l	22,092	130,798	26,880	101,093	866,393
Apts., rooming houses	290,695	22,739	58,401	....	....	....	16,197	....	399,662	....	1,562	....	62,891	68,499	28,511	949,157
Dwellings	2,983,298	1,679,836	1,511,395	619,592a	747,157	3,741,824	633,597	163,489	3,114,804	1,019,111	141,243	348,855	1,074,437	524,887	2,118,926	20,422,451
III. Mercantiles																
Office bldgs., banks	138,377	51,737	8,340	....	....	1,179,427	21,044	....	62,145	....	338	1,736	25,786	9,175	35,240	1,533,345
Restaurants, taverns	163,186	18,297	76,267	....	....	157,416	43,094	....	192,796	16,525	....	1,855	66,770	25,316	211,541	973,063
Barber, beauty shops	6,120	....	2,444	....	....	7,744	3,092	....	20,408	....	725	413	9,127	....	679	50,752
Misc. mercantiles	1,730,389	564,709	609,515	740,891b	372,673b	1,582,376	280,307	184,582b	2,080,626	330,820b	178,701m	206,562	712,285	436,798	935,619	10,946,853
Warehouses	225,474	175,078	122,949	....	45,590	619,455	358,609	2,514	309,955	283,329	....	8,912	547,633	11,503	425,974	3,136,975
IV. Manufacturing																
Metal workers	26,673	3,760	6,604	2,525	9,143	33,608	....	....	1,455	13,986	125	390	36,189	....	60,984	195,442
Woodworkers	2,458	....	2,711	1,675	29,136	11,946	....	....	....	1,198,030	....	38,927	387,439	....	8,562	1,680,884
Flour mills, elevators	3,198,884	140,640	64,838	49,760	772	....	194,171	205,638	....	59,678	23,445	75	81,578	....	43,856	4,063,335
Packing plants, stockyards	....	3,872	3,023	....	....	....	....	....	4,119	....	200	....	17,009	....	....	28,223
Bakeries	5,690	12,097	97,760	27,720c	....	8,204	....	....	18,106	....	....	397	26,215	....	7,777	203,966
Laundries	22,825	10,481	651	4,303d	11,120d	48,591	6,844	....	50,322	....	100d	....	20,221	....	8,134	183,592
Cleaners, tailors	21,172	605	726	....	....	18,623	....	....	5,474	....	....	....	203	1,400	11,762	59,965
Misc. Manufacturing	1,253,805	642,210	449,170	50,688	176,314	2,289,282	101,567	17,156	2,010,949	285,300	3,327	10,690	571,544	43,275	317,710	8,222,987
V. Miscellaneous																
Barns	1,224,983	694,207	752,411	753,154e	185,835i	440,453	225,721	255,594i	1,012,879	336,299k	98,401k	738,252e	113,268	76,670	1,195,327	8,103,454
Outbuildings	205,711	85,297	161,361	....	....	35,242	43,941	....	83,372	....	....	75,558	78,254	71,640	100,512	940,888
Lumber yards	100,942	45,049	60,390	32,180	31,722	130,281	61,940	....	201,351	....	35,684	....	208,454	11,500	23,453	942,946
Railroads, wharves	87,493	2,225	14,696	4,371	5,968j	89,921	....	703	21,345	22,341	2,912	2,126	....	....	145,599	399,700
Bulk oil storage, refineries	69,692	520	2,230	14,186f	....	....	....	10,170	....	4,918	1,417	....	2,500	....	....	105,633
Garages, filling stations	408,766	92,770	163,270	5,573g	6,721	143,540	77,114	44,614	332,205	15,295	17,471	31,006	60,256	53,611	178,356	1,630,568
Power plants, pump houses	9,680	10,348	4,980	....	....	21,823	....	....	....	....	750	18,824	1,715	....	41,160	109,280
Creameries, dairies	....	21,923	1,041	....	....	....	....	....	....	....	5,020	25,874	12,069	....	49,008	114,935
Miscellaneous buildings	298,671	13,369	193,672	24,115	98,413	112,893	87,718	52,002	624,176	93,254	865	33,433	17,359	146,000	18,865	1,814,805
Motor vehicles, aircraft	182,246	35,360	45,127	33,765	15,073	77,459	30,605	3,475	105,086	26,556	7,603	....	....	2,190	148,143	712,688
Outdoor fires	68,810	71,116	7,882	....	....	85,670	....	....	....	....	2,572	1,393	580	....	3,991	242,014

Table III. Number of Fires by Causes in Fifteen States — 1939.

Causes	Illinois	Indiana†	Iowa	Kansas	Louisiana	Massachusetts	Nebraska	North Dakota	Ohio	Oregon*	South Dakota	Vermont	Washington	West Virginia	Wisconsin	Total
Chimneys, flues — defective, overheated	876	385	353	230	130	755	132	114	1,616	652	80	528	282	63	2,780	8,976
Sparks on roofs	2,276	817	1,222	283	170	290	167	28	3,685*c*	429	....	28	167	....	....	9,562
Defective or overheated heaters	1,281	300	165	262	134	374	134	209	863	603	25	187	264	....	711	5,512
Rubbish	1,577	75	26	35	67	....	....	7	1,022	23	56	22	....	11	220	3,141
Combustibles near heaters	....	3	22	....	....	301	....	....	1,149	....	....	....	92	19	281	1,867
Open lights, flames, sparks	377	101	396	63	140	350	171	66	....	127	66	66	474	4	561	2,896
Hot ashes, coals	309	211	64	126	138	160	37	71	511	481	15	87	99	4	261	2,574
Oil burners	....	....	20	....	....	137	....	....	....	....	13	....	....	....	211	381
Smoking	2,540	189	423	288*b*	608*b*	2,513	204	328	3,833	1,779*b*	78	353*b*	907	24	2,791	16,858
Children and matches	....	....	87	....	....	437	75	....	830	....	37	....	52	8	254	1,780
Matches	....	97	80	....	....	318	....	....	790	....	6	....	4	4	407	1,706
Electrical	1,942	247	512	328	238	1,051	155	105	2,433	526	84	100	265	24	1,517	9,527
Electrical appliances, motors	98	75	23	16	94	79	10	42	224	251	13	34	58	....	510	1,527
Flammable liquids, home dry cleaning, starting fires	914	73	127	87	193	541	47	123	624	82	33	166	79	6	281	3,376
Torches, welding	....	37	58	....	....	76	....	....	325	....	9	....	6	....	81	592
Films	....	....	6	....	....	....	....	....	19	....	2	....	1	....	7	35
Lamps and stoves	....	72	287	....	....	339	201	....	428	....	77	....	13	3	607	2,027
Gas and appliances	106	32	5	24	69	18	6	29	128	....	7	12	....	5	134	575
Grease, tar, etc.	143	....	29	38	49	122	16	52	248	328	1	42	237	....	314	1,619
Spontaneous ignition	533	125	215	101	31	467	117	53	762	123	43	17	58	10	310	2,965
Fireworks	35	4	1*a*	6	7	117	2	4	22	12	2	5	....	....	43	260
Lightning	277	112	119	82	157	112	60	98	242	32	24	215	11	10	2,178	3,729
Thawing pipes	....	....	9	....	....	47	....	....	53	....	....	....	....	....	10	119
Sparks from machinery, friction	11	8	12	13	36	67	15	9	145	61	3	8	8	....	30	426
Incendiary, suspicious	134	31	43	17	44	411	20	18	291	76	6	3	67	34	116	1,311
Miscellaneous	163	115	153	20	35	37	83	16	1,533	25	67	15	692	2	301	3,257
Unknown	1,859	921	762	850	652	526	429	220	1,991	792	99	416	1,082	253	1,022	11,874
Explosions	364	156	....	116	26	....	11	38	176	70	34	12	86	....	219	1,308
Exposure	1,302	122	190	252	277	221	52	122	952	399	40	135	216	50	348	4,457

*Number insurance claims, not number of fires.
†Fiscal year ending June 30, 1939.

a. Prohibits fireworks.
b. Includes matches.
c. Includes sparks from stacks.

†Fiscal year ending June 30, 1939.

b. Includes matches.
c. Includes sparks from stacks.

Table IV. Fire Loss by Causes in Fifteen States — 1939.

Causes	Illinois	Indiana†	Iowa	Kansas	Louisiana	Massachusetts	Nebraska	North Dakota	Ohio	Oregon	South Dakota	Vermont	Washington*	West Virginia	Wisconsin	Total
Chimneys, flues — defective, overheated	$460,216	$391,593	$314,872	$130,387	$90,980	$512,806	$89,624	$93,494	$442,296	$212,654	$25,965	$110,225	$131,385	$94,688	$574,128	$3,675,313
Sparks on roofs	694,098	308,013	410,449	62,053	48,834	126,056	45,985	10,303	500,170c	188,220	....	15,268	58,953	....	311,729	2,780,131
Defective or overheated heaters	533,626	253,139	216,910	244,075	49,745	447,163	134,452	210,619	349,661	231,726	19,093	72,778	99,820	....	305,357	3,168,164
Rubbish	261,514	52,751	7,843	10,700	6,431	....	....	1,980	456,467	8,387	7,453	3,719	....	10,990	46,410	874,645
Combustibles near heaters	....	1,613	2,967	....	....	264,441	....	....	235,921	....	....	....	19,237	13,847	48,599	586,625
Open lights, flames, sparks	120,138	28,735	112,495	12,388	39,174	209,747	39,270	18,913	....	13,381	23,529	18,475	160,957	195,750	160,795	1,153,747
Hot ashes, coals	55,854	78,496	9,647	27,100	49,993	113,902	9,922	15,074	98,809	84,117	20,314	14,719	5,858	3,075	36,612	623,492
Oil burners	....	....	26,441	....	....	164,481	....	....	....	....	2,611	....	....	....	42,547	236,080
Smoking	286,735	168,252	172,203	75,943b	206,870b	1,851,550	71,574	74,361	511,625	163,603b	16,260	26,843b	160,143	50,910	289,711	4,126,583
Children and matches	....	....	9,802	....	....	148,727	15,610	....	94,140	....	7,517	....	6,019	8,325	46,515	336,655
Matches	....	37,557	21,951	....	....	207,575	....	....	124,175	....	662	....	81	3,600	20,483	416,084
Electrical	1,178,363	419,107	416,484	154,066	69,793	1,445,280	134,327	50,813	883,348	376,455	92,283	62,438	169,143	45,025	944,077	6,441,002
Electrical appliances, motors	74,722	37,896	2,704	9,927	19,627	60,879	5,463	22,286	56,084	8,099	1,646	1,276	6,930	....	45,019	352,558
Flammable liquids, home dry cleaning, starting fires	317,149	45,020	58,651	14,809	142,702	285,019	22,994	34,535	113,551	13,215	5,177	75,643	22,606	13,400	99,874	1,264,345
Torches, welding	....	82,105	114,669	....	....	65,383	....	....	34,911	....	265	....	328	....	26,102	323,763
Films	....	....	3,193	....	....	....	....	....	5,583	....	1,703	....	1,190	....	1,071	12,740
Lamps and stoves	....	45,154	139,452	....	....	273,352	74,072	....	137,568	....	38,109	....	9,920	550	133,340	851,517
Gas and appliances	64,062	119,346	7,436	11,831	23,162	22,366	1,857	51,021	80,333	....	845	2,201	....	35,400	37,405	457,265
Grease, tar, etc.	87,356	....	6,619	7,325	6,524	58,394	7,615	5,759	113,517	16,350	6,500	5,782	18,367	....	33,601	373,709
Spontaneous ignition	431,513	196,524	316,838	97,788	66,033	1,155,429	168,119	50,394	452,532	171,222	44,598	49,607	86,941	16,995	476,055	3,780,588
Fireworks	4,624	619	10a	855	88	32,353	65	1,977	6,564	633	300	343	....	....	6,807	55,238
Lightning	394,117	174,332	276,509	151,377	39,275	192,522	115,789	41,356	216,934	12,628	14,632	88,786	3,198	18,889	348,464	2,089,008
Thawing pipes	....	....	17,636	....	....	29,808	....	....	5,341	....	....	....	....	....	1,489	54,274
Sparks from machinery, friction	4,850	10,663	13,118	13,854	3,352	140,667	21,342	4,069	18,604	48,276	1,056	14,089	5,042	....	23,214	322,196
Incendiary, suspicious	613,050	178,391	27,907	29,194	101,333	783,863	28,985	31,065	267,494	182,156	6,182	174	69,612	91,175	317,824	2,728,405
Miscellaneous	143,510	27,961	72,050	7,733	50,097	38,991	27,181	15,634	689,639	22,642	20,477	5,845	274,976	172,500	95,273	1,664,509
Unknown	4,906,310	1,952,274	1,809,377	1,360,228	810,647	2,961,230	1,142,991	374,072	4,685,024	1,265,996	198,175	1,013,124	2,916,645	862,690	1,570,453	27,829,236
Explosions	1,677,006	112,971	....	66,644	27,127	....	28,191	40,988	103,438	42,182	25,084	12,288	20,128	....	34,017	2,190,064
Exposure	1,747,465	142,709	157,676	152,185	102,851	180,294	108,346	88,868	370,321	904,067	22,466	99,176	152,401	108,190	299,383	4,456,104

*Insurance losses only.
†Fiscal year ending June 30, 1939.

a. Prohibits fireworks.
b. Includes matches.
c. Includes sparks from stacks.

Table VI shows the total estimated number of fires and fire losses distributed by occupancies and based on the data in the previous tables. Table VII shows similar figures by causes. These occupancy and cause classifications are not listed in any order of importance, but are grouped so that similar classes come together. Each class is broad in scope in order to reduce the number of classes to a minimum and permit the compilation of a sufficient amount of data on each to be of value. Several of the fire marshals' reports use much longer lists of occupancies and causes by subdividing the general classes shown in the accompanying tables. For example, some states divide the occupancy class "Dwellings" into "City Dwellings" and "Farm Dwellings," and the cause class "Lightning" into "Rodded" and "Unrodded."

To arrive at the estimates shown in Tables VI and VII the procedure outlined above was applied to the figures for each class in previous tables, except for those classes where data were lacking from several states. In such instances proportional increases in the total estimates were made. For example, some states did not give figures for fires in "Barber, beauty shops," and the total number of barber and beauty shop fires and losses was therefore increased by about one-third the total reported by the nine states. A corresponding reduction was then made in other classes. In this particular example the "Miscellaneous" and "Mercantile" classes were reduced, as it is likely that the states not reporting barber and beauty shops used these classes for recording such fires.

Taking another example, seven states did not report the number of fires or amount of the fire loss due to the cause "Matches." Accordingly the totals

Table V. Fires per 1000 Population and Fire Loss per Person for Fifteen States, 1939, as Reported by Fire Marshals.

State	Population 1940 Census	Number Fires	Fires per 1000 Population	Fire Loss	Fire Loss per Person
Illinois	7,874,155	17,117	2.17	$14,056,278	$1.78
Indiana	3,416,152	4,310	1.26	4,865,221	1.42
Iowa	2,535,430	5,409	2.14	4,745,909	1.87
Kansas	1,799,137	3,237	1.80	2,640,462	1.47
Louisiana	2,355,821	3,295	1.40	1,954,638	0.83
Massachusetts	4,312,332	9,645	2.24	11,592,001	2.69
Nebraska	1,313,468	2,264	1.72	2,293,774	1.75
North Dakota	639,690	1,751	2.74	1,237,581	1.92
Ohio	6,889,623	24,895	3.63	11,054,050	1.60
Oregon	1,087,717	6,871	6.28	3,966,009	3.66
South Dakota	641,134	920	1.43	602,910	0.94
Vermont	357,598	2,451	6.87	1,692,799	4.74
Washington	1,721,376	5,220	3.04	4,399,880	2.55
West Virginia	1,900,217	534*	——	1,745,999	0.92
Wisconsin	3,125,881	16,505	5.30	6,376,354	2.04
Total	39,969,731	104,424	2.62	$73,223,865	$1.83
Estimated U. S. Total	131,409,881	685,000	5.24	$300,000,000	$2.29

*Incomplete.

Table VI. Estimated Distribution of U. S. Fire Losses by Occupancies, 1939.

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies, and while they are reasonable approximations based on the experience in typical states they should not be taken as exact records for each class.

Occupancy	No. of Fires	Loss
I. PUBLIC BUILDINGS		
Government buildings	1,000	$600,000
Hospitals, institutions	900	450,000
Schools	3,200	8,500,000
Churches	2,800	4,000,000
Theatres	1,200	2,800,000
Amusements, halls	4,200	3,300,000
II. DWELLING OCCUPANCIES		
Hotels, boarding houses	10,000	3,500,000
Apartments, rooming houses	43,000	6,500,000
Dwellings	340,000	82,000,000
III. MERCANTILES		
Office buildings	7,500	8,600,000
Restaurants, taverns	12,000	5,400,000
Barber, beauty shops	1,500	350,000
Miscellaneous mercantiles	43,500	41,000,000
Warehouses	7,500	14,750,000
IV. MANUFACTURING		
Metal workers	1,600	1,000,000
Woodworkers	2,000	11,000,000
Flour mills, elevators	2,500	8,200,000
Packing plants	900	300,000
Bakeries	1,500	1,100,000
Laundries	1,000	850,000
Cleaners, tailors	1,200	450,000
Miscellaneous manufacturing	13,000	30,000,000
V. MISCELLANEOUS		
Barns	36,000	33,300,000
Outbuildings	30,000	5,000,000
Lumber yards	1,100	4,850,000
Railroad, wharf property	4,000	2,000,000
Bulk oil storage, refineries	1,500	1,000,000
Garages, filling stations	27,000	6,700,000
Power plants, pump houses	1,500	650,000
Creameries and dairies	900	1,200,000
Miscellaneous buildings	10,000	5,500,000
Automobiles	65,000	3,350,000
Outdoor fires	6,000	1,800,000
Totals	685,000	$300,000,000

NOTE: As explained in the text, 100 per cent has been added in estimating the number of fires, and 25 per cent has been added to the losses to cover unreported losses.

reported by the eight other states were increased and corresponding reductions were apportioned among the class "Smoking," under which it is assumed that the seven states probably recorded fires caused by matches.

As previously emphasized, these fire experience figures are approximate estimates, but give a fair indication of the distribution of losses by occupancy and cause classifications.

Table VII. Estimated Distribution of U. S. Fire Losses by Causes — 1939.

These estimated figures are intended to show the relative order of magnitude of fire losses by causes, and while they are reasonable approximations based on the experience in typical states they should not be taken as exact records for each class.

Cause	No. of Fires	Loss
Chimneys, flues—defective or overheated	58,000	$15,000,000
Sparks on roofs	79,500	14,000,000
Defective or overheated heaters	19,000	8,600,000
Rubbish	26,000	4,000,000
Combustibles near heaters	15,000	4,500,000
Open lights, flames, sparks	7,500	1,700,000
Hot ashes, coals	16,000	2,500,000
Oil burners	7,000	2,000,000
Smoking	87,000	14,000,000
Children and matches	23,000	2,500,000
Matches	22,000	3,200,000
Electrical	55,000	26,000,000
Electrical appliances, motors	10,000	1,500,000
Flammable liquids, misc., including home dry cleaning and starting fire	20,000	4,000,000
Torches, welding	8,000	2,700,000
Films	1,000	150,000
Lamps and stoves	22,000	5,200,000
Gas and appliances	4,000	1,900,000
Grease, tar, etc.	10,500	2,000,000
Spontaneous ignition	19,500	15,400,000
Fireworks	1,500	200,000
Lightning	24,000	8,500,000
Thawing pipes	1,000	350,000
Sparks from machinery, friction	3,000	1,300,000
Incendiary, suspicious	8,500	11,000,000
Miscellaneous	11,500	6,800,000
Unknown	78,000	114,000,000
Explosions	10,500	9,000,000
Exposure	37,000	18,000,000
Totals	685,000	$300,000,000

NOTE: As explained in the text, 100 per cent has been added in estimating the number of fires, and 25 per cent has been added to the losses to cover unreported losses.

Camden, New Jersey, Conflagration.

A fire following a series of explosions in the R. M. Hollingshead Corporation plant at Camden, N. J., on July 30, 1940, quickly assumed conflagration proportions due to ignition of large quantities of flammable liquids used in the manufacture of such items as auto grease, oil, anti-freeze, metal polish, wax, auto-top dressing, tire coating, brake fluid, paint remover, soap, antiseptics, and insecticides. Ten persons lost their lives as a result of the explosions and resulting fire and more than one hundred others are reported to have received treatment for injuries. In addition to destroying a block of factory buildings, the blaze spread to near-by rows of dwellings, leaving sixty families homeless. The total loss was estimated at close to $2,000,000.

Outstanding lessons of the fire are the importance of locating processes involving flammable liquids in properly protected and detached fire-resistive buildings, the importance of proper zoning to segregate manufacturing and residential areas, and the fact that no public fire department can be expected to overcome the inherent hazards found in such large conflagration breeding occupancies once private protection fails or is inadequate.

Weather Conditions.

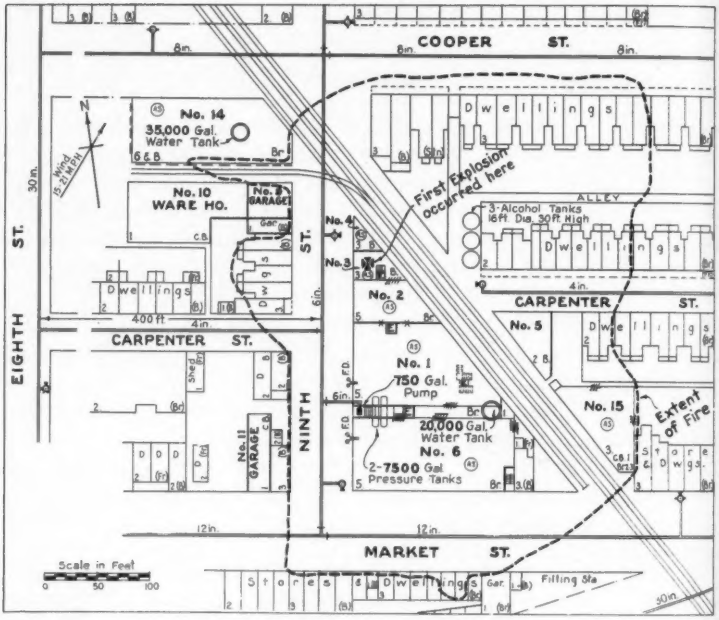
The weather at the time of the fire was almost ideal for a conflagration. The temperature reached a peak of 94 degrees during the fire and averaged 85 degrees for the entire day. A fifteen to twenty-one mile per hour southwest wind was blowing.

It is interesting to note that a wind-squall of almost "hurricane force" occurred between 6:30 and 7 P.M., just an hour after the fire was declared to be under control. It is said that this wind threatened to spread the fire further and it is considered fortunate that it did not occur earlier.

Construction and Arrangement.

The main compact group of plant buildings occupied a triangular block 255 feet along North 9th Street and 158 feet along Market Street, Camden. It backed up to a railroad right of way for 240 feet. These buildings were mainly of five-story and basement brick, plank and timber construction, and were numbered 1, 2, 3, 4, and 6. These buildings were fully occupied for the manufacture of a wide variety of materials, involving the use of flammable oils

NOTE: This account has been prepared from information contained in reports on this fire by the National Board of Fire Underwriters (member N.F.P.A.); Eastern Underwriters Inspection Bureau (member N.F.P.A.); Associated Factory Mutual Fire Insurance Companies (Member N.F.P.A.); Camden Fire Insurance Association (member N.F.P.A.); and other sources.



and solvents in various portions of the buildings. There were apparently many mixing and storage tanks located throughout this main group of plant buildings and the explosion hazard was recognized to be severe.

The concern was organized about 1900 to manufacture harness dressing. The original plant was a five-story building of heavy timber construction shown on the plan as Building 1. An extension of the number of products included a metal polish and numerous other polishes using benzine and other solvents of low flash point. About 1915, two three-story buildings also of heavy timber construction were built to house all processes involving the use of highly flammable liquids. These Buildings, shown as 3 and 4 on the plan, were the buildings in which the initial blast occurred. At later dates Buildings 2 and 6 were constructed, combining the group essentially into one large building, subdivided by fire walls with single or double non-standard automatic fire doors on communicating openings between Nos. 3 and 4, between Nos. 2 and 3 and between Nos. 1 and 6.

Windows facing the blind court between Buildings 1 and 6 were of plain glass in wooden frames in Building 1, and wired glass in metal frames in Building 6. The windows in the upper floors of Building 2 overlooking Building 3 were also of wired glass in metal frames. There were unprotected openings between Buildings 1 and 2.

Across the railroad tracks at the rear of the main group was Building 5, a two-story brick building, and Building 15, a three-story brick building. Eighty feet distant across North 9th Street on the opposite side of the main group of plant buildings was Building 14, an eight-story and basement building of fire-resistive construction protected by automatic sprinklers. This building was occupied in the basement and first floor by a wholesale liquor dealer and on the fourth floor by a corset manufacturer, but elsewhere by the R. M. Hollingshead Corporation for office, printing and storage purposes. Also across North 9th Street was a small one-story garage designated as Building 9.

With the exception of the two small buildings Nos. 5 and 9, all plant buildings in the fire area were fully sprinklered with wet pipe systems having three water supplies, including pressure tanks, gravity tanks, and city water supplemented by a 750-gallon electrically driven centrifugal booster pump. In addition, each building of the main group except Building 4 had a vertical standpipe with hose connected at each floor, and chemical fire extinguishers and water pails, well distributed.

Processes.

Processes in Buildings 1, 2 and 6 included the manufacture of soaps, greases, insecticides and the filling of containers with these products, as well as the blending and canning of lubricating oils. All liquids used in the processes in these buildings were in a class with kerosene, or had higher flash points. In Buildings 3 and 4 processes involved the use of such low flash point solvents as naphtha, alcohol and gasoline. Products included polishing wax, rubber cement, gasket cement, cigarette lighter fluid, and auto top dressing; processes also included the filling of containers with these materials.

Flammable liquids were stored in underground tanks located near the intersection of Ninth and Cooper Streets, and along the east side of Ninth Street, whence they were piped to the basements of Buildings 3 and 4. Distribution from there was carried on through steam driven pumps; with storage tanks more than half full, these pumps would be under a gravity head. In addition to these materials, which were used in bulk, smaller quantities of miscellaneous solvents in drums were stored on the fourth floor of Building 2.

In Buildings 3 and 4 were large, vertical mixing tanks of up to about 500 gallons capacity, extending from the third down through the second floor, and terminating on the first floor in gravity-fed fill pipes used for filling containers with the finished product. Ingredients were put into the mixers at the third floor level. Covers were provided for tanks, each being held open by a fusible link, and the tanks were grounded. Solvents were piped to tanks from pumps in the basement. Mixing vanes in the tanks were operated by belts from a shaft extending through walls from Building 2, where an induction type electric motor driving the shaft was located. Tanks used for such processes as the

Wide World.

Looking east over the entire area of the Camden, N. J., conflagration of July 30, 1940. In the foreground may be seen wagon pipes and an aerial ladder stream operating as a water curtain at Ninth and Market Streets to protect exposures from the intense fire in R. M. Hollingshead Corp. Building 6. Across the tracks behind Building 6 flames are sweeping Building 15. At the extreme left are the burning dwellings on Cooper Street near the plant building in which the first explosion occurred.

manufacture of wax polish were heated by steam jacket. The steam plant was located in the basement of Building 1.

A 36-inch fan was located in one of the windows on the third floor of Building 4; as far as can be ascertained, this was the only provision in either Buildings 3 or 4 for the removal of vapors. Several lighting fixtures in Building 4 were of the vapor-tight type, and an electric motor on the first floor of Building 3 was of explosion-proof type; all other electrical equipment in these two buildings was of non-explosion-proof type.

Events Preceding the Fire.

During the morning of July 30, operations were carried on as usual at the plant; it is reported that the only process carried on in Building 4 was the filling of containers with polishing wax; no operations were carried on in Building 3. At the time of the fire most of the employees had returned from lunch, with four women employees returning to the first floor of Building 4 to carry on with the operation of filling containers with polishing wax. One male employee was also working on the first floor of Building 4. An employee went to the basement of Building 3, presumably to work in the rag-washing room. It is reported that the plant watchman was on the second floor of Building 3, at his locker near the elevator shaft, eating his lunch; that one other employee was in the same part of the building.

Story of the Fire.

There are reports indicating that there was a breakdown in the machinery which sent molten wax by gravity from wax tanks on the third floor to the filling room where cans were automatically filled before women employees placed lids on the cans. It is said that hot wax had backed up in a vat and that several employees had started up to the third floor to report the difficulty when the initial blast occurred.

The first explosion is reported to have occurred in the lower floors of Building 3 near the northern apex of the triangular group of plant buildings. The explosion was described as a deep rumbling sound and appears to have been of considerable violence. A number of windows in Buildings 3 and 4 were blown out and some reports state that portions of the brick walls were also blown out.

Portions of the first floor dropped into the basement and it is reported that employees from both the first floor and basement were trapped in the flaming débris. Several employees are said to have been blown from the plant by the explosion. In any event three men were found on the Ninth Street side of Building 2 with their clothing ablaze. Two others were found on the railroad tracks near the freight door of Building 3 with their clothing also ablaze. A man working in Building 4 was also found on the tracks behind the building with his clothing aflame.

fire in R. M. Hollingshead Corp. Building 6. Across the tracks behind Building 6 flames are sweeping Building 15. At the extreme left are the burning dwellings on Cooper Street near the plant building in which the first explosion occurred.

International.

During the late stages of the Camden conflagration of July 30, 1940, firemen are shown concentrating their attention on buildings ignited due to exposure to the main blaze in the R. M. Hollingshead Corp. plant.

Persons who lost their lives as a result of the fire included four women employed in the basement wax department, five men employees including the watchman, and a city fireman who died of a heart attack while working in the ruins of the factory.

At the time of the first explosion between 1:05 and 1:10 P.M., about 300 employees were in the building. About 50 others had not returned from lunch due to staggered periods. A number of employees in the sections nearest to the initial explosion found themselves trapped by flames and were forced to jump from windows to escape. Others are reported to have struggled down crowded inside stairways or outside iron fire escapes. It is indicated that a man who tended the wax filling machine was on the third floor repairing the faulty wax feed when the explosion occurred and he escaped with his life.

The effect of the explosions appears to have been felt over a considerable area. Windows in a three-block area were broken, with the flying glass adding to the number of injured.

Spread of the Fire.

The fire quickly involved large quantities of flammable liquids and spread throughout the main group of buildings. The wind carried the fire across the railroad tracks and radiated heat ignited buildings across Ninth Street. Dwellings along Cooper and Carpenter Streets were ignited and destroyed. It is said that explosions caused the roofs of some of these dwellings to be sprayed with burning flammable liquids, hastening their destruction.

A half hour after the fire started two tank cars on a siding beside the plant exploded. Another car filled with alcohol previously was pushed out of danger by workmen. Three large undyked alcohol storage tanks east of the railroad tracks were protected with hose streams and did not ignite. They were equipped with screened vents and at least one of them overflowed, probably due to expansion of the contents.

Fire Fighting Operations.

The first alarm was received at fire alarm headquarters at 1:15 P.M., from a box at the corner of Ninth and Penn Streets, one block north of the nearest building involved in the fire. An aerial ladder and two engine companies, together with a deputy chief, responded. The chief also responded, since he desired to investigate the explosion.

Upon the arrival of the chief, Buildings 2 and 3 appeared to be totally involved, together with parts of Buildings 4 and 1. The fire was extending rapidly across the upper floors of Building 1. Pumpers were connected to hydrants and a hand line was taken in and up the stairway between Buildings 1 and 6. Before this line had been put into operation, a second explosion took place, occurring somewhere in the vicinity of Building 3. The fire then extended

During the late stages of the Camden conflagration of July 30, 1940, firemen are shown concentrating their attention on buildings ignited due to exposure to the main blaze in the R. M. Hollingshead Corp. plant.

International.

Firemen with hand lines are shown checking the spread of the fire to the east along Market Street, Camden.

across the court and through the door and window openings into Building 6. The hand line was withdrawn and played into the lower floor windows along the west side of Building 6, in an attempt to check the fire at the north wall of this building. A ladder pipe was put in service in the same location with the similar intent. However, within ten minutes after the first alarm it became obvious that the plant could not be saved.

Fire alarm operators report that the first explosion occurred some five to eight minutes before the first alarm was received at 1:15 P.M. The extent of the fire could be observed from fire alarm headquarters. Accordingly, when an alarm was received at 1:17 P.M. from a box located at the corner of Eleventh and Cooper Streets, it was treated as a second alarm and two engine companies and an additional ladder company were sent to the fire. This box was sounded again at 1:19 P.M., and two more engine companies were despatched. At the same time one of the principal pumping stations of the water department was notified by telephone.

The chief ordered a general alarm by telephone at 1:28 P.M. and all companies in the city were despatched to the fire. The total response comprised nine engine companies and three ladder companies, with a total of 18 pieces of apparatus. A call for help was sent to Philadelphia at 1:38. A ladder company and two engine companies were sent under command of a battalion chief. These were followed a few minutes later by an additional engine company. A fourth engine company was sent at about 3 P.M. A large number of policemen and an ambulance also responded from Philadelphia.

The Camden fire department devoted its services to protecting exposures on the south, east and west. An attempt to prevent the fire from crossing the railroad tracks from the Market Street end was thwarted by the intense heat

H. V. Tucker.

Firemen are shown attempting to check flames which destroyed this row of buildings along Cooper Street during the conflagration starting in the plant of the R. M. Hollingshead Corp.

and flames as shown by accompanying photographs. Companies from Philadelphia were assigned to Cooper Street, fighting the fire as it spread throughout the dwellings along the southern side of this street.

At the height of the fire, it is estimated that twenty-eight hand lines, with 1-inch or 1⅛-inch tips, were in use; in addition, a ladder pipe, with 1½-inch tip, as well as three turret nozzles, each with 1¾-inch tips, mounted on hose wagons, were used.

Off-shift members of the fire department were not called, but a number of them responded to the fire grounds voluntarily upon learning of the fire.

Little information is available as to the action of the private fire protection. It is reported, however, that upon arrival the fire department found several hose lines connected to the header of the private fire pump, but no information was obtainable as to when or where these lines may have been used. The lack of information regarding these hose lines suggests the possibility that a fire had occurred previous to the first explosion. The possibility that either the first explosion ruptured the sprinkler piping or that sprinklers were shut off following the fire, is said to be under investigation.

In any event, the fire spread rapidly throughout the plant, punctuated by a series of explosions, including at least twenty-eight distinct blasts. By 2:30 P.M. the walls of the Hollingshead plant began to collapse. Much water was wasted from broken sprinkler piping and hydrants. By the time Building 15

Wide World Photos.

The Camden conflagration as recorded from the corner of Ninth and Market Streets. At the left, the upper floors of R. M. Hollingshead Corp. Building 6 are badly involved. The stream from the fire department wagon pipe is not yet reaching the fire. At the right, heavy streams are operating on the fire and on Market Street exposures as the walls of the factory begin to fall. Below, firemen are protecting exposures against the intense heat from the ruins of No. 6 Building.

the right, heavy streams are operating on the fire and on Market Street exposures. Firemen are protecting exposures against the intense heat from the ruins of No. 6 Building.

International.

Looking east toward the main plant group of the R. M. Hollingshead Corp. At the extreme left is the fire-resistive plant office building which escaped destruction, although damaged by explosions, smoke and water.

across the railroad right-of-way became ignited the sprinklers in that building were apparently without water due to the rupturing of sprinkler mains resulting from the collapse of the main plant buildings.

During the fire, Chief John Lennox of the Camden Fire Department was overcome by heat prostration and Deputy Chief Walter Mertz took charge. A number of other firemen were overcome or injured in addition to one who lost his life due to a heart attack.

It is said that several firemen were overcome when a seam let go in some gas tanks that they were trying to protect with hose streams. Others are said to have been overcome by fumes given off by the ruins of the factory after the fire was under control.

About 10:30 P.M. firemen wearing asbestos suits and gas masks attempted to search the ruins for bodies of the victims, but were forced to give up due to the intensity of the fire.

In accordance with outside aid arrangements recently completed, companies were called by fire alarm headquarters from Audubon, Collingswood, Merchantville and Haddon Heights. These went in service at fire stations previously assigned. Apparatus thus put in service consisted of four pumpers, a city service ladder truck, and a pumper-ladder truck. These companies remained in service until 11:25 A.M., July 31, when the first company was released. The last company left early Monday morning, August 5. During the time that outside aid companies were in service in Camden, twenty-two alarms of fire were received at fire alarm headquarters. Operators and officers of these companies were familiar with the city and had been schooled in the operation of the Camden system of despatching companies. In general, these departments have volunteer firemen with paid drivers.

Some seven or eight other neighboring towns, hearing of the extent of the fire, sent companies to the fire. These included the departments of Haddonfield, Mount Ephraim, Pennsauken, Gloucester, and Westville.

The first aid squad and ambulance of the Gloucester fire department were on duty throughout the night. Sixty members of the R.C.A.-Victor Corporation first aid squad also worked to relieve firemen suffering from the terrific heat.

The Philadelphia Navy Yard sent several truckloads of U. S. Navy floodlights. These were useful to aid in patrolling the fire area after dark, as well as aiding the firemen.

While outside fire companies were being welcomed, radio stations were asking sight-seers to keep away from the city. To enforce this request the Federal Street bridge over the Cooper river was raised to stop the flow of cars into town.

Philadelphia Evening Bulletin.

Looking north across Market Street, Camden, during the conflagration of July 30, 1940. Flames from R. M. Hollingshead Building 6 may be seen rolling across the railroad tracks where they ignited Building 15 at the right. Flames may also be seen enveloping one of the tank cars on the siding adjoining the plant. Several tank cars are reported to have exploded during the blaze.

Looking north across Market Street, Camden, during the conflagration of July 30, 1940. Flames from R. M. Hollingshead Building 6 may be seen rolling across the railroad tracks where they ignited Building 15 at the right. Flames may also be seen enveloping one of the tank cars on the siding adjoining the plant. Several tank cars are reported to have exploded during the blaze.

Acme.

Remains of the Cooper Street dwellings as firemen cool down the ruins of the Camden, N. J., conflagration of July 30, 1940.

It is reported that several homes were looted during the fire. The American Legion called out three hundred men to guard the furniture of fire refugees until the National Guard arrived.

Public Water Supply.

The public water supply, which is direct pumping, stood up well during the fire. Extra pumps were started promptly and the pressure was raised about twenty pounds above normal. After a few hours this extra pressure was found to be unnecessary and it was discontinued. It is estimated that about five million gallons of water was used on the fire, but because the Campbell Soup Company, which uses an average of ten million gallons daily during the summer season, voluntarily shut down, the total consumption in the city on the day of the fire was less than on either the day previous or the day following. Large mains in the vicinity of the fire helped to maintain good pressure. As an additional precaution street sprinklers and public pools were shut off during the fire. During the height of the fire there were six extra waterworks pumps in use and an ample number were in reserve.

Fire companies responding from outside departments were directed to pump from the Cooper River about four blocks from the fire. One of the Philadelphia pumpers operating at this point nearly worked itself into the river and had to be towed to safety.

Acme.

View along Cooper Street, Camden, during the height of the conflagration of July 30, 1940. The plant office building in the foreground escaped destruction, although a tenant liquor store on the basement and ground floors suffered heavy water damage.

It is evident that adequate quantities of water at moderate pressure were available in the larger mains in the vicinity of the fire. Four-inch mains in several of the streets in the neighborhood may have limited the supply to several pumpers, and at least one was forced to relocate at a larger main. As most of the operation was from hydrants on the larger mains there was no shortage of water which would handicap the fire department.

Origin of the Fire.

The cause of the initial explosion and subsequent fire is attributed to the ignition of flammable vapors. Lack of complete explosion-proof electrical equipment introduced numerous sources of ignition. In addition an employee reported to have been repairing equipment in Building 3 may have struck a spark. That there was a large accumulation of flammable vapor appears indicated by the fact that men in Buildings 3 and 4 were found outside with their clothing on fire.

Whatever the source of ignition, there was ample opportunity for accumulations of flammable vapors. High atmospheric temperatures on the day of the fire, together with inadequate facilities for the removal of vapors from the buildings, provided an ideal condition for the formation of explosive mixtures in the basements and lower floors of the plant.

Zoning.

Following the fire, the N.F.P.A. Committee on City Planning and Zoning made some inquiry as to whether Camden had a zoning ordinance at the time of the fire, and if so in what zone the factory was located. The Committee was

informed by the City Clerk that the city had no zoning ordinance and that the dwellings that were destroyed or damaged were built both prior to and subsequent to the erection of the factory.

Record Protection.

A large safe dragged from the ruins of the Hollingshead factory by firemen was opened the day after the fire. Two thousand formulas dating back twenty years had been destroyed, but duplicates kept in the main office building are available. These were transferred to safe deposit boxes for safe-keeping.

Extent and Loss.

In addition to the complete destruction of the main group of plant buildings, the fire-resistive office Building 14 sustained general damage to windows by the explosions and the basement was flooded. It is also reported that girders supporting the water tank at the roof of this building were damaged. Plant Buildings 5 and 15 across the railroad tracks were also destroyed.

Thirty-two dwellings on Cooper, Carpenter, North Ninth, and Market Streets were destroyed and thirty-one others were damaged by the fire and explosions.

Nearly sixty automobiles parked on streets in the fire area were destroyed or badly damaged.

The total loss resulting from this conflagration has been estimated at about $2,000,000, with insurance losses of between $1,000,000 and $1,500,000, including substantial use and occupancy losses.

* * * *

A Fatal Flammable Liquid Fire.

AUGUST 17, 1940, MCDONALD, KANS. Careless handling of gasoline resulted in the death of a 16-year-old boy. The youth and a companion were refueling a farm tractor, drawing the gasoline from one of two barrels in a truck and carrying it in a ten-gallon milk can to the tractor. One of the boys is reported to have stepped back some twenty feet to light a cigarette, but the wind carried gasoline fumes to him and these flashed back to the truck and to the tractor. The boys started fighting the fire and finally brought it partly under control. At this point one of the boys started to drive the truck away in the hope of reaching home, where water was available. The movement of the truck caused more gasoline to spill and the fire in the back of the truck gained in intensity. After he had driven nearly a mile, the second barrel of gasoline exploded from the heat, breaking the rear cab window and spraying the driver's back with burning gasoline. Realizing he could stay no longer with the burning truck he attempted to bring it to a stop but found the hydraulic brake hose had been burned away and the brakes would not operate. Jamming the truck into second gear, he jumped. The truck was consumed by the fire and the boy died several hours later in a hospital. (L-06252.)

Hercules Powder Company Explosion.

Fire and subsequent explosions in the Kenvil, N. J., plant of the Hercules Powder Company on September 12 caused the death of 49 men, injuries to between 100 and 200 persons, and property damage variously estimated at between $1,000,000 and $2,000,000. Possible sabotage was suspected and a number of official investigations were started by federal and state government and by other agencies. As this issue of the QUARTERLY goes to press, no official report is available and it may well be that in this case, as in the case of some other outstanding disasters of previous history, no official report will be available until such a long time after the disaster that it has little practical application to current fire protection problems. The property was not insured, so there is no information available from insurance sources. The details of the disaster are accordingly more or less a matter of conjecture.

The Hercules Powder Company is an old established concern in this field and lack of experience in the manufacture and handling of explosives cannot be cited as a contributing cause. The company had every incentive for fire and explosion prevention; it carries its own insurance. It has for years maintained a safety department, held membership in the N.F.P.A., and given every evidence of interest in fire safety.

This disaster occurred in a new section of the plant, which has recently been expanded to provide facilities to fill U. S. government orders. The building where the initial fire and explosion occurred was a new section that had only been in operation for a few days. Despite extensive publicity suggesting the possibility of sabotage, there has to date been no evidence to indicate that this disaster was in any way attributable to the work of foreign agents.

Hazards and Separation of Units.

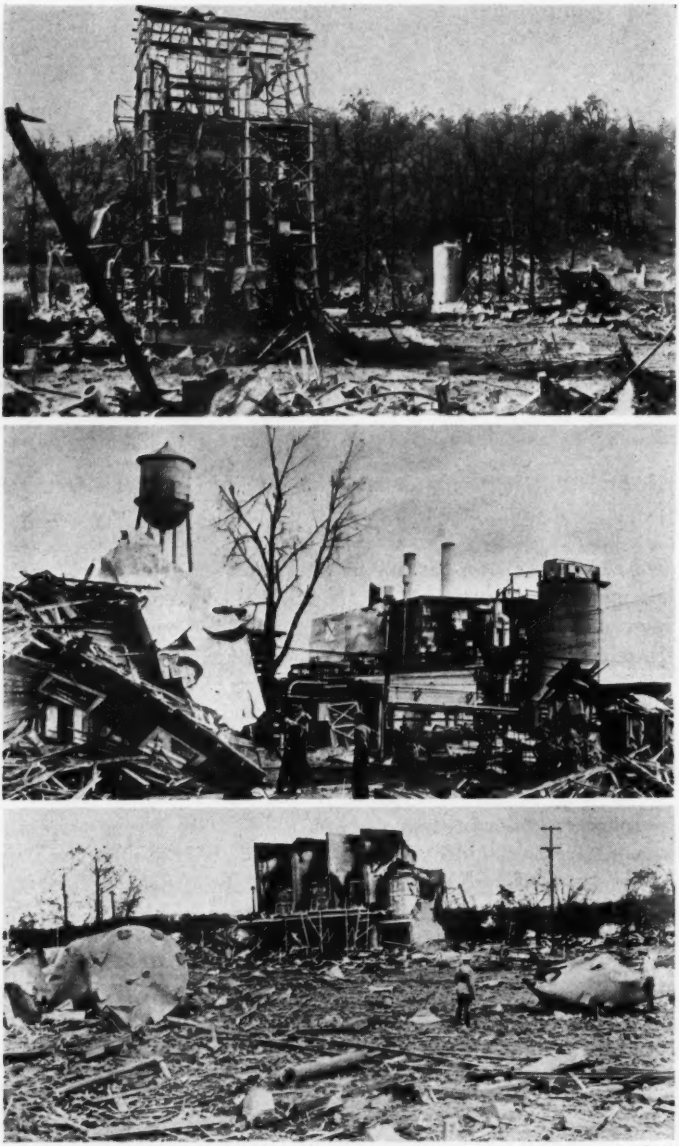
Explosives manufacturing is inherently hazardous and it is standard practice to conduct such operations in isolated sections of the country, well away from built-up areas, and to subdivide the manufacturing operations into small units, separated from each other by distance and by barricades to minimize the possibility of the propagation of explosion from one unit to another. The Kenvil plant of the Hercules Powder Company was designed in accordance with this practice. It was in a sparsely settled section and the individual buildings were well distributed over a 400-acre wooded area. Units were separated by distances of several hundred to a thousand feet. The value of this separation was demonstrated in this case by the fact that another section of the plant devoted to dynamite manufacturing was little affected by the explosion and con-

Air view of the smoldering ruins. Note explosives storage house behind barricade in left foreground, untouched by the explosion.

tinued in production with only a minimum of interruption. Some twenty thousand pounds of powder and a large underground nitroglycerine storage were not ignited.

It is definitely known that the series of explosions started with a fire in the solvent recovery building. This initial fire, apparently involving ether vapor, seems to have been a flash fire that quickly developed into an explosion or series of explosions. In the process of manufacture of smokeless powder, the nitrocellulose is dissolved in alcohol and ether. One of the final operations is the removal of the solvents and as the ether particularly represents a very considerable value in any large scale operation, equipment had been installed to condense and recover the ether after its evaporation from the powder. It is a well-known fact that any solvent recovery process involving flammable solvents is a hazardous operation because of the likelihood of the presence of explosive mixtures of solvent vapor and air, either continuously or during some stage of the process. In the present case, it appears that the ether was evaporated by air and that an explosive mixture of ether vapor and air was present in the equipment. That the nature of the hazard had been recognized by the company was shown by the provision of elaborate fire protection equipment, particularly a deluge type sprinkler system thermostatically operated and adjusted for almost instantaneous operation.

The initial fire or explosion — there seems to have been no sharp dividing line between the fire and explosion — occurred at 1:29 P.M. Events thereafter progressed so rapidly that it is impossible to tell just what happened and why the sprinkler protection was ineffective. Although some statements have been made that the amount of nitrocellulose material in the building of origin was



Three views of different sections of the plant, showing the complete destruction.

not sufficient to account for any such explosion, the natural assumption is that the burning or exploding ether spread to the nitrocellulose, causing an explosion which in turn propagated to other supplies of smokeless powder in various stages of manufacture located in other near-by units, of which eight were destroyed. Whatever may have been the exact cause and sequence of events, the photographs show that the destruction was complete. The force was such that in addition to the destruction of the immediate plant area windows were reported broken at distances of from five to seven miles and there was considerable damage to a number of buildings in the vicinity. It was only the isolated location of the entire plant that prevented far more extensive damage. A school half a mile from the plant was slightly damaged, and a few children hurt by glass, but by following the regular fire drill procedure a thousand high and grammar school students were marched out with no panic.

The deaths were due both to burns from the fire and the force of the explosion. Of the 1500 plant employees there were some 75 to 100 men working in the building where the initial explosion occurred. Practically all these men were either killed or seriously injured. Many are still in hospitals as this account is written.

Aid was immediately summoned from surrounding communities and fire fighting operations were started. Before any effective fire fighting could be undertaken, however, the damage had been done. The plant fire brigade, organized for fire emergencies, went into action, but could do little in a disaster of this magnitude. Firemen from surrounding communities responded and the removal of the injured was handled without delay.

* * * *

Other Fatal Explosions.

AUGUST 20, 1940, GIBBSTOWN, N. J. Four men were killed when a shack used for packing dynamite into paper cartridges blew up. The shack was part of a large explosives manufacturing plant. It was in the center of the dynamite manufacturing area, but was at least 500 yards from all other plant buildings. A twelve-foot earth barricade around the shack smothered the force of the blast and confined damage to other buildings to broken windows. (L-06242.)

AUGUST 19, 1940, SPRINGFIELD, MASS. Four men were fatally burned by an explosion of volatile vapors in a vinyl acetate resin manufacturing plant. The men had just started the polymerization process of the chemicals and it is stated that the chemical change occurred prematurely. The explosion blew the welded cover from the tank and this is believed to have damaged electrical wiring, causing a spark which ignited the vapors. The fire-resistive qualities of the building and special explosion-venting construction, together with the prompt work of the private fire brigade, halted the fire quickly. (L-06239.)

Air view of the destruction of the California Building at the Golden Gate International Exposition August 24, 1940.

San Francisco World's Fair Fire.

By Thomas McCaughern, District Secretary,
Board of Fire Underwriters of the Pacific (Member N.F.P.A.).

On August 24, 1940, fire swept and largely destroyed the California State Building at the Golden Gate International Exposition on Treasure Island, San Francisco. Considering the large areas of combustible construction, the fact that this was the first major fire at either of the current "World's Fairs," may be regarded as something of a tribute to the effectiveness of the fire defenses provided for the expositions, both at New York and San Francisco. Failure to prevent the destruction of the building occupied by the California Commission to the Exposition is attributed to the failure to provide automatic fire alarm service in a one-story frame addition constructed against the east wall of the destroyed building several months after the original structure was completed. Only efficient fire fighting efforts prevented destruction of other seriously exposed fair buildings connected to the burned structures.

The burned building was designed and occupied as the headquarters of the California Commission to the Exposition. It contained the offices of the Commission and numerous departments, but was essentially a place of assembly. Displays of paintings, objects of art and historical documents were prominent features of this exhibit.

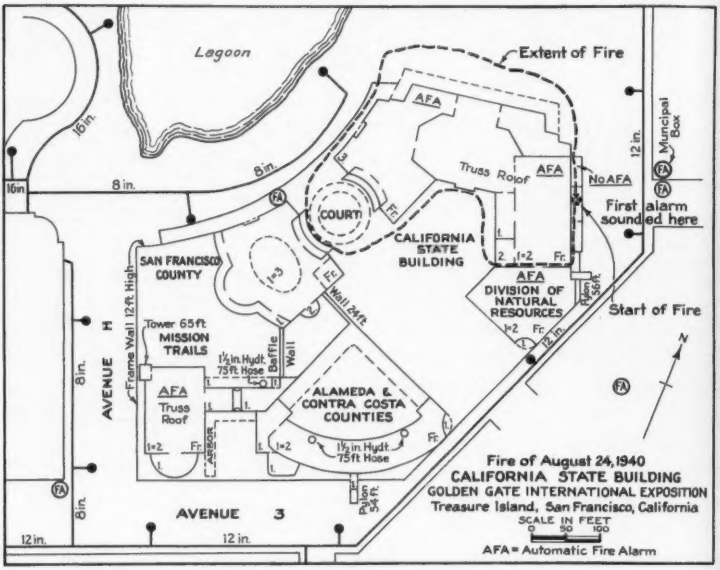
Construction and Protection.

Construction of the California building was wood frame throughout. Foundations were of 3 x 12 x 48-inch mats and 12 x 14-inch mudsills. There were wooden piles under the colonnades. Except for a comparatively small area thirty-two feet in height the building was fifty-six feet high. It was both two story, and one equals two and three story in arrangement with a ground floor area of 30,000 square feet. The roof was tar and gravel on sheathing on 2 x 12-inch joists supported by built-up wooden columns and trusses. The roof space averaged ten feet, with skylights of metal frame with wired glass. Interior partitions were plasterboard and plyboard on 2 x 6-inch wooden studs. Exterior walls were of plyboard on 2 x 6-inch studs. Floors were of wood.

The building as originally constructed was protected by an approved installation of automatic fire alarm service. This protection, however, was not extended to the frame addition, although recommendations were made that a circuit be installed to protect this area.

First aid fire protection consisted of fifteen 2½-gallon soda-acid extinguishers. In addition there were five units of standpipe and hose. California State Police maintained hourly watchman and clock service at night. A detail of eight State Police officers were on duty in and about the building at the time of the fire.

Air view of the destruction of the California Building at the Golden Gate International Exposition August 24, 1940.



Story of the Fire.

Origin of the fire in so far as can be determined was in a storeroom located in the north end of the frame addition to the California State Building. It was first observed by an Exposition guard and an employee of the California Commission. An alarm was promptly turned in from a box situated 110 feet east and directly across the street from the fire. The receipt of this alarm was recorded at 9:20 A.M. and was almost simultaneous with the receipt of an automatic alarm.

Following the arrival of apparatus from the Exposition fire stations, Battalion Chief Rudonick, in command of the Exposition fire department detail, turned in an alarm at 9:25 A.M. from a city box, bringing apparatus from the mainland under Chief Charles J. Brennan. It is estimated that apparatus began arriving at the scene within ten minutes after the alarm and continued to arrive as quickly as it could be assigned. A total of five alarms were sounded from the city box.

The following equipment and personnel responded to the various alarms: 27 engine companies, 14 ladder companies, 5 water wagons, 3 water towers, 1 rescue squad, 2 fireboats with 53 officers and 252 men. Hose used totaled 60,600 feet of various sizes, and 42 ladders were used, including one 85-foot aerial ladder.

Upon the receipt of the first alarm, fireboat No. 2 stationed in the Port of Trade Winds, Treasure Island, immediately connected to the shore manifold

Publicity Dept. Golden Gate International Exposition.

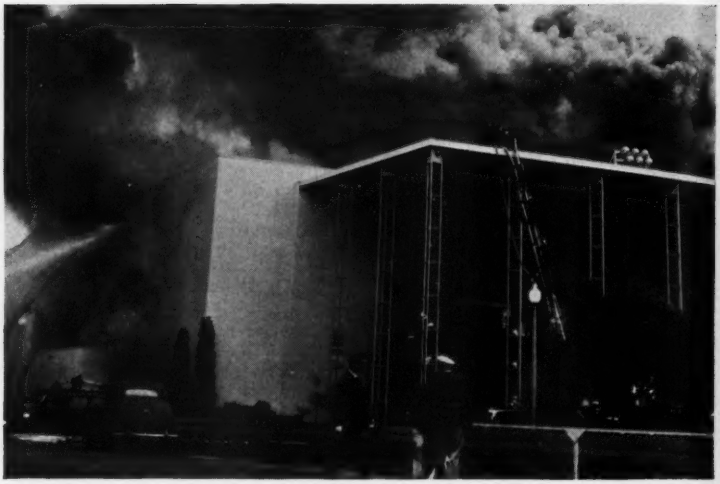
The start of the fire in the one-story unprotected addition.

and stood by until at 9:48 it started drafting from the bay and continued pumping until 10:05, when it left to find a point of better vantage, but returned to its regular station and connected to the manifold and again began drafting. During the time of drafting the fresh water from the Yerba Buena Island reservoir was automatically cut off.

Upon the receipt of the second alarm at 9:26 A.M. fireboat No. 1 was ordered to proceed to Treasure Island and upon arrival ten or more minutes later was docked approximately 1500 feet east of fireboat No. 2. With the assistance of 160 sailors from two U. S. Navy mine layers, ten 3-inch hose lines were connected to the boat and laid approximately 1100 feet to the fire, supplying batteries (heavy streams), towers and single streams. The boat was in service six hours and thirteen minutes, pumping at 250 pounds pressure. In addition to streams supplied by the fireboats, six to eight pumpers, varying according to need, drafted from the lagoon situated 100 feet from the fire.

Spread of the Fire.

The fire department reports that it was able to check the initial blaze in the storeroom, but when this had been done, it was found that the fire had spread to the roof space and was beyond control. The fire spread rapidly through the unfinished area between the exterior east wall of the main building and the interior wall of the ballroom into the roof space, through which it spread over the entire building due to lack of adequate fire stops.



International.

Firemen may be seen carrying four hose streams over an aerial ladder to points of vantage on the roof of the burning California Building at the Golden Gate International Exposition. Forty-two ladders were used in fighting this fire. Men and equipment came from the mainland and began arriving ten minutes after the first alarm was received. All together, five alarms were sounded.

Meanwhile the work of removing contents was started. A detachment of 200 soldiers stationed on the Island volunteered to aid in this work. Valuable service of this disciplined group resulted in saving practically all the works of art and other historical objects. Exposition guards and state police aided in removing records and furnishings.

The building was completely gutted with the exception of a small section occupied by the Department of National Resources. The fire was confined within the walls of the destroyed section, which still stand. At about 1:00 P.M. the fire was under complete control and most of the apparatus released.

The San Francisco Building is situated eighty feet south of the California Building and joined to it by a circular frame colonnade. For a time it appeared likely that the fire would spread to this structure, and it is a tribute to the efficiency of the fire department that such damage was entirely averted.

Weather conditions on the morning of the fire were cool and overcast, with a seven-mile westerly wind and high humidity. Temperature range was 60 to 63 degrees F.

An emergency program set up in 1939 governed the functions of the various service units and played an important part in meeting the contingencies of this situation.

International.

A battery of heavy streams from water towers is shown in a successful effort to check the fire in the California building before flames spread to the adjoining San Francisco buildings. Fire pumpers drafted water from the Lagoon in the foreground. Nearly a dozen miles of hose was used in controlling this fire.

Units involved in the plan:

United States Army
United States Navy
California State Highway Patrol
California State Police
San Francisco Fire Department
San Francisco Police Department

Exposition Departments:

Utilities
Public Works
Transportation
Medicine
Guards
Guides

Cause and Conclusions.

The cause of the fire might be attributed to either careless smoking, defective wiring, spontaneous ignition, or other causes. Candor requires the admission that no satisfactory evidence is offered in support of any of these and the cause remains unknown.

This fire has again demonstrated the following fundamentals. First: automatic fire detecting, automatic sprinkler, or other protective systems are dependable for maximum protection only when such installations are complete. Failure to protect a small area nullified the effectiveness of the automatic alarm service in this instance. Second: Large area of combustible roof spaces should be cut up into small fire divisions by substantial fire stops.

Fortunately, as stated, most of the contents of the burned building were removed safely. The building and contents were entirely covered by insurance. Insurance covering the building was written with a "diminution clause," taking into account the fact that the Exposition is scheduled to close this autumn.

Fires in Which There Was Loss of Life.

Third Quarter, 1940.

The Department of Fire Record has received reports of ninety-three fatal fires in the United States and Canada since the publication of the July, 1940, QUARTERLY. Three hundred and sixteen persons lost their lives as a result of these fires. During the period stated the following fires were reported which resulted in the death of five or more persons each.

JUNE 3, 1940, EDMUNDSTON, N. B., CANADA. Six members of a private fire brigade lost their lives while fighting a fire which destroyed part of a 12,000 cord pile of pulpwood. Four of the victims were killed instantly when the top of the burning pulpwood conveyor collapsed on them, the other two suffering fatal injuries. (H-43798.)

JULY 12, 1940, CINCINNATI, OHIO. Five women were killed and seven other persons injured in a fire which swept through a four-story hospital building, trapping most of the thirty occupants until firemen could carry them down ladders. The fire is believed to have started in the basement boiler room. The patients, most of whom were asleep on the upper floors, were aroused shortly

Loss of Life by Fire, July-September, 1940.*

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Occupancy	No. Fires	Men	Women	Children	Total
Aircraft	4	17	1	0	18
Apartments, hotels, lodgings, tenements, etc.	9	11	2	0	13
Boats and ships (except tank vessels)	2	1	1	0	2
Dwellings—rural	17	2	7	20	29
Dwellings—urban	18	4	14	5	23
Dwellings—trailers	1	0	1	0	1
Forest and brush fires	3	3	0	0	3
Hospitals and institutions	1	0	5	0	5
Manufacturing occupancies	13	87	4	0	91
Mercantile occupancies	1	0	1	0	1
Mining property	2	57	0	0	57
Motor vehicles (except tank trucks)	9	9	1	2	12
Tank trucks	1	1	0	0	1
Oil refineries and bulk distributing plants	2	2	0	0	2
Out-of-door fires	3	8	0	1	9
Railroad rolling stock**	1	43	0	0	43
Response to alarms	1	2	0	1	3
Other known buildings	1	1	0	2	3
Total	93	248	37	31	316

*This table is made up from those reports received by the Department of Fire Record between June 21, 1940, and September 13, 1940. A few of the fires included herein occurred prior to June 21, but were not reported until subsequent to that date.

**Reports received by the N.F.P.A. are not clear as to the sex of all the victims of the Akron, Ohio, train wreck which occurred July 31. Indications are, however, that most if not all were men.

Acme.

This fire, which occurred July 12, 1940, in a Cincinnati, Ohio, hospital, took the lives of five women and caused injuries to seven other persons.

after midnight by smoke. They found the main stairway in flames, and the outside fire escape is reported as having been "too hot for use." (H-43800.)

JULY 16, 1940, SONMAN, PA. Forty-seven miners were killed in a coal mine explosion. Further details are lacking. (H-43802.)

JULY 19, 1940, NEWBERRY, MICH. A mother and four children died when their farm home was struck by lightning and burned to the ground. (H-43803.)

JULY 30, 1940, CAMDEN, N. J. Six men and four women were killed in a fire which destroyed most of the R. M. Hollingshead plant. (See page 157.)

JULY 31, 1940, AKRON, OHIO. Forty-three persons were killed in a fire resulting from a collision between a gasoline-electric railway coach and a freight train. (See page 142.)

AUGUST 16, 1940, JOPLIN, MO. An explosion of unknown origin in the dynamite section of an explosives plant killed five workmen. (H-43804.)

AUGUST 27, 1940, BATES, ARK. Ten men were killed when an explosion occurred in a coal mine. (H-43805.)

AUGUST 29, 1940, BUFFALO, OKLAHOMA. At least six men were burned to death and three others were critically burned when a flash fire occurred while they were working on a gasoline pipeline. The cause of the fire was not determined. (H-43806.)

SEPTEMBER 12, 1940, KENVIL, N. J. A series of explosions at a powder manufacturing plant resulted in the death of forty-nine persons.

Causes of Loss of Life, July-September, 1940.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause of Fatality	Men	Women	Children	Total
Aircraft fires	17	1	0	18
Asphyxiation (smoke and gas suffocation)	1	6	0	7
Children alone in house	0	0	1	1
Children playing with matches	0	0	3	3
Clothing ignited:				
1. Furnaces, stoves, and heaters	0	1	0	1
2. Smoking and matches	1	0	0	1
3. Smoking in bed	2	1	0	3
4. Miscellaneous	0	2	0	2
Escaping fire; jumped, fell or drowned	1	1	0	2
Explosions:				
1. Ammonia	1	0	0	1
2. "Empty" tanks	2	0	0	2
3. Explosives	61	0	0	61
4. Fireworks	2	0	1	3
5. Liquefied Petroleum Gases	0	1	0	1
6. Manufactured and nautral gases	1	3	0	4
7. Miscellaneous and unknown	1	0	0	1
Fire fighting—firemen	12	0	0	12
Flammable liquids and vapors:				
1. Gasoline and similar liquids:				
(*a*) Stoves, lamps, and torches	0	1	1	2
(*b*) Used for cleaning purposes	1	1	0	2
(*c*) Used to kindle fire	0	1	3	4
(*d*) Miscellaneous	2	0	0	2
2. Kerosene, range oil, and fuel oil:				
(*a*) Stoves, lamps, and torches	0	0	1	1
(*b*) Used to kindle fire	0	3	0	3
3. Miscellaneous and unknown	11	0	0	11
Forest and brush fires (including fire fighting)	3	0	0	3
Indirect causes (overexertion, exposure, etc.)	0	1	0	1
Marine fires	1	1	0	2
Mine fires and explosions	57	0	0	57
Motor vehicle fires (except tank trucks)	7	1	2	10
Tank trucks	1	0	0	1
Railroad rolling stock fires	43	0	0	43
Response to alarms	2	0	1	3
Trapped in burning buildings	18	12	18	48
Total	248	37	31	316

ANOTHER LARGE-LOSS FIRE...

that DIDN'T happen!

It was a perfect "set-up" for a blaze of major proportions

...when fire broke out, shortly after 3:00 a.m., in the basement of the Krupp & Tuffly shoe concern in Houston...

Stored in the basement were boxes, cartons, and other flammable materials ordinarily found in a retail shoe establishment. An elevator shaft provided a nearby vertical artery to spread flames and smoke throughout the three floors above. And there was no one on the premises...

Yet with all these conditions—unavoidable, yet "ideal" for the rapid spread of fire—*there was no loss.* For the executives of this concern long ago realized that certain fire and smoke damage hazards were inherent in the nature of their business, and adopted A.D.T. Aero Automatic Fire Alarm protection. Their foresight was well repaid on this occasion, for Aero automatically detected the outbreak at the very start, and automatically summoned the fire deparment in time to extinguish the blaze with chemicals before any damage resulted.

Every year there are scores of such "large-loss fires THAT DON'T HAPPEN," *thanks to A.D.T. Aero Automatic Fire Alarm. For Aero eliminates the hazards of belated discovery and delayed alarms, which are the underlying causes of most large-loss fires.*

A. D.T. AERO AUTOMATIC FIRE ALARM

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CENTRAL STATION OFFICES IN ALL PRINCIPAL CITIES OF THE U.S.

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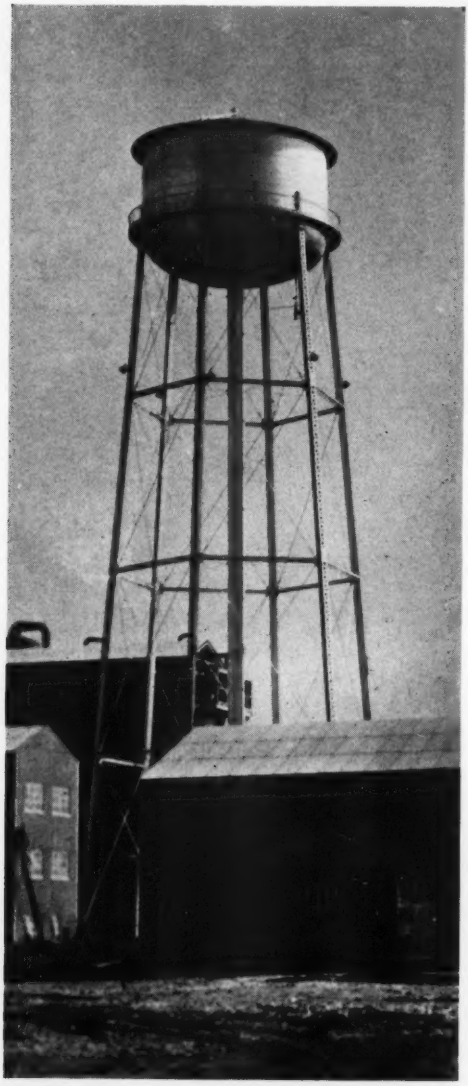
Electric Protection Services

AGAINST FIRE · BURGLARY · HOLDUP

A NATION-WIDE ORGANIZATION



DEPENDABLE FIRE PROTECTION for your PLANT

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Horton elevated water tanks are built in standard sizes from 5,000 to 2,000,000-gals. Installations for fire protection usually range from 40,000 to 300,000-gals. Heights to bottom vary to suit your pressure needs, and if desirable, additional capacity may be included in sprinkler tanks to furnish water for general use.

Write for the new booklet "Fire Protection". Call our nearest office for information or estimates on the cost of the elevated storage you need.

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SAFETY FILMS

Watchman Supervision with a DETEX CLOCK

CLOSE supervision by watchmen is the best fire protection any plant can have.

But watchmen are human and a supervisory system gives permanent proof that those watchmen were alert—that they made their regular rounds. The Detex line includes watchmen's clocks specifically designed to meet any watchman's supervisory problem. No matter what the size of the plant—no matter how many watchmen employed—a Detex clock on the job will mean greater protection.

The general acceptance by industry of the Detex System of watchman supervision is indicated by 100,000 Detex watchclocks in nightly operation.

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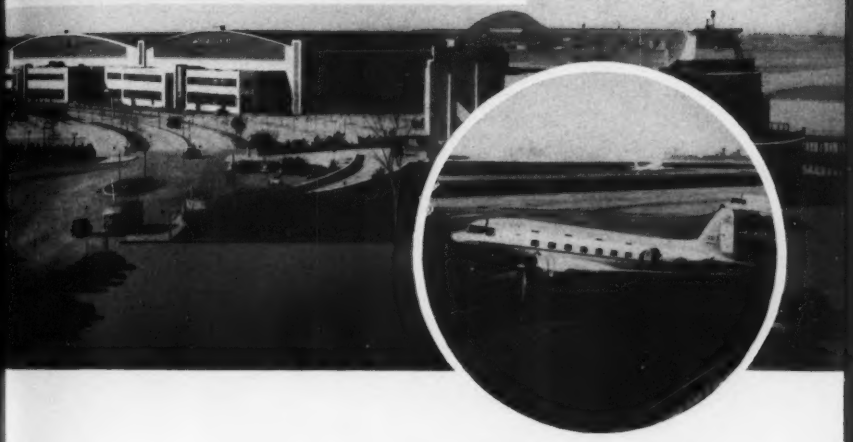
SUPROTEX-DELUGE
Sprinkler System



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THIS highly perfected sprinkler system, combining Rate-of-Rise (instant) fire detection with open (immediate discharge) sprinklers, has fully met the needs of one of the most extreme of all fire hazards — the airplane hangar. Here, huge airplane values are at stake under conditions where fire, once out of control, means complete destruction — an event which would impair the national defense. America needs *all* her airports — intact. "Automatic" has developed Rate-of-Rise sprinkler systems for every type of risk. Whatever your sprinkler system problem may be — we can solve it. Ask for complete information.

Contracts recently closed for Suprotex-Deluge Systems for U. S. Naval Air Stations at: Corpus Christi, Texas; San Juan, Puerto Rico; Alameda, Calif.; Jacksonville, Fla.; Midway Islands, Pacific Ocean.

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DESIGN, MANUFACTURE AND INSTALLATION OF AUTOMATIC SPRINKLER SYSTEMS FOR ALL TYPES OF PROPERTIES

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. . . an AUTOMATIC device that POSITIVELY maintains PROPER air pressure in the sprinkler system

ACCEPTED by insurance underwriters, this TYDEN device is the *only* one available today that maintains positively at all times the proper amount of air pressure in dry pipe sprinkler systems. High air pressure is not only undesirable but is extremely detrimental to the operation of the system . . . the TYDEN Pressure Maintenance Device receives air from any constant source at any pressure higher than maximum required, and automatically delivers and maintains the proper pressure in the sprinkler system. Eliminates possibility of human or mechanical errors. Minimizes claims for fire or water damage. Pays for itself many times in maintenance costs. Talk it over with your VIKING man.

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You Can't Burn **PYRANOL!**

WHAT IT IS

Pyranol is General Electric's noninflammable insulating liquid used in transformers and other electric equipment. Being noninflammable, Pyranol prevents fire hazard from the liquid, and has the approval of the Underwriters' Laboratories, Inc. The National Electrical Code permits the installation of Pyranol transformers indoors without using expensive fireproof vaults as previously required for indoor transformer installations.

WHAT IT MEANS

Pyranol transformers make possible radically new methods of installation. Valuable space can be saved by placing them on the main floor, in the basement, on overhead beams, or even on the building roof—all without the use of a fireproof vault. Savings in construction materials and in secondary copper, because Pyranol transformers can be placed close to the load, often make the Pyranol transformers the most economical as well as the safest installation possible.

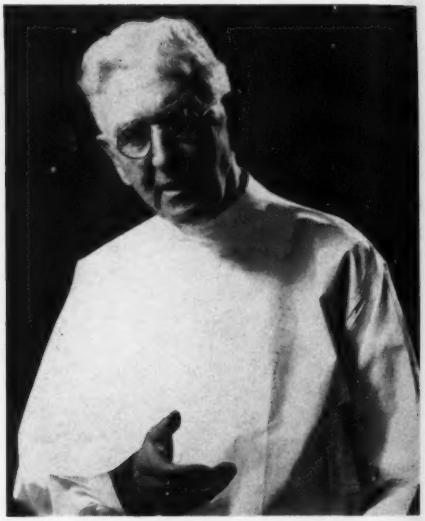
GET COMPLETE INFORMATION

It will pay you to investigate Pyranol transformers. Remember—every *Pyranol* installation is a *fireproof* installation—you can't burn Pyranol. For additional information, call your nearest G-E representative or write for Bulletin GEA-2637. Address General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

200-87

It's Too Late!



After the smoke of a disastrous tank truck accident has cleared, it is useless to do wishful thinking on SAFETY. Human life and the conservation of equipment and property depend on decisions reached before the accident happens.

In case of collision or fire, S. & J. Hydraulic Internal Safety Valves protect the driver, the load, and the equipment. Their SAFETY is attested by Underwriters' Laboratories. Their installation in truck tanks spells real SAFETY to the petroleum transporter and takes a load off the Fire Chief's mind.

SHAND & JURS CO.

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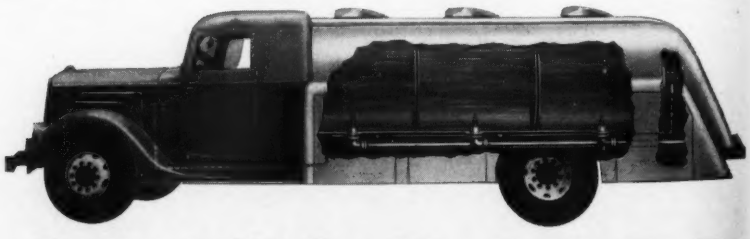

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HOFFMAN 140·F

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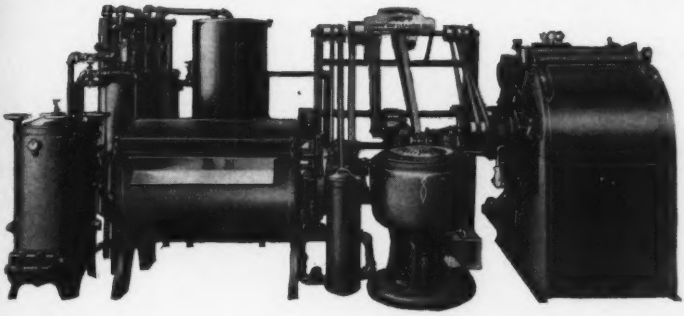

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The Hoffman 140F dry cleaning unit employs a new solvent with flash point of approximately 140° F. The unit has many unusual features, including a drying tumbler with temperature automatically controlled throughout the drying cycle.

Here for the first time is a petroleum solvent unit which has been granted listing by the Underwriters' Laboratories, Inc., under their Reexamination Service. Such listing, of course, assures fire authorities and insurance rate-making bureaus that 140F Units will be built to specified standards and will be properly inspected. While we are at all times interested in promoting greater safety in the use of dry cleaning equipment, we are especially proud of this new development which sets entirely new safety standards for petroleum solvent cleaning.

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TESTED & LISTED AS A COMPLETE UNIT

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National Fire Protection Association

INTERNATIONAL

Organized 1896

EXECUTIVE OFFICE: 60 BATTERYMARCH STREET, BOSTON, MASSACHUSETTS

All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. Members receive a handsome membership certificate.

We furnish free to members the Standards issued by the National Board of Fire Underwriters, and the lists of devices and materials inspected by Underwriters' Laboratories, Inc.

The Association is the clearing house for all the authoritative information on Fire Protection and Prevention and members are privileged to submit to it their individual problems for solution.

PUBLICATIONS

Quarterly Magazine of the Association. A chronicle of the Association's activities, with valuable contributions of articles on fire prevention and protection and special hazards, and compilations of fire statistics on various classes of property.

News Letter. A special monthly bulletin of timely information on fire prevention and kindred subjects.

Proceedings of Annual Meeting. Containing stenographic report of transactions of the Association and the discussions incident to the adoption of its standards.

Special reports, bulletins, etc., issued frequently during the year.

Year-book and directory. Complete list of members with addresses.

Index to all subjects covered in the Printed Records.

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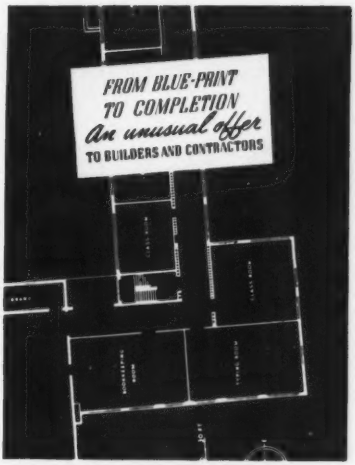

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